

Nibiru & Nemesis = preuves



Some scientists think a brown dwarf or gas giant bigger than Jupiter could be at the outer reaches of the solar system. In this image showing relative size, the white object at the upper left edge represents the sun.

**Comparaison des dimensions de la terre avec Jupiter ,
une naine brune , le soleil et une étoile de faible masse**

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Nibiru 2012: El Planeta X se acerca a la Tierra y ya es visible a simple vista

Una vez cada 3,600 años Nibiru se acerca al nuestro sistema solar, de acuerdo a cálculos este planeta sera visible a finales del 2012 a simple vista

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RUSIA. Los rusos ya no ocultan que el llamado **Planeta X, o Nibiru** según otros se acerca a la Tierra y sus consecuencias pueden llegar a ser catastróficas.


en el cielo hay un nuevo objeto, un punto rojizo débil anteriormente solo observado por astrónomos, pero después de **mayo del 2012 puede ser visto a simple vista**. Este sería el planeta oscuro Nibiru, las probabilidades de la existencia de este planeta en nuestro sistema solar NASA solo lo reconoció en 1982.

Ya hace 5,000 años los sumerios lo nombraban "Disco Alado" y argumentan que la aparición de nibiru en el cielo amenaza con problemas mortales.

Nibiru o el Planeta X, visible arriba del Sol naciente

Earth HAS shiften on it's Axis - PROOF!!! (Edited)

Tinkoneofsix S'abonner 144 vidéos



Ajoutée par Tinkoneofsix le 28 janv. 2012

NASA: Earthquake in Chile shifted Earth's axis

65 aiment, 6 n'aiment pas

Plusieurs médias en ont parlé ouvertement

more crowded people and to prevent auto traffic to late 1970s. Continued on Page 15

Lesson from history— 10th planet? Pluto's orbit says 'yes'

By HARRY HUGHES News Staff Writer

New evidence from the U.S. Naval Observatory of a 10th planet in the solar system is mounting, and some astronomers believe that the discovery, an ancient eastern Mediterranean civilization, were far ahead of modern man in astronomy.

Astronomer Thomas Van Flinders told a meeting of the American Astronomical Society in Albuquerque this week that registration in the orbit of Pluto, the furthest known planet from the sun, indicates that the solar system contains a 10th planet.

Pluto was the last planet discovered, in 1930. Since then, astronomers have been searching unsuccessfully for planets farther out. Indeed, Pluto had not even been photographed but remained unphotographed for a long time because it was so difficult to see. Presently, say other new planets would be easy to spot visually.



Superior label in East Berlin shows a solar system with sun, moon and 10 planets.

planet is four times the size of Pluto and 1.5 times its distance from the sun.

Van Flinders's announcement comes as an surprise to Barbara Stille, whose book, The 10th Planet, came out three years ago.

STILLE, who describes herself as a Russian-born linguist and archeologist, says that the Sumerians, who date back 4,500 years, knew of a planet beyond Pluto. They named it the 10th planet, he explains, because, in their system of reckoning, the sun and moon are also counted as planets. He Sumerian name was Nibiru.

Continued on Page 154

Heavenly body poses a cosmic riddle to astronomers

By Thomas O'Toole

WASHINGTON—A heavenly body that could be anything from a newly formed galaxy to a planetary nebula is the subject of a mysterious discovery by an astronomer at the University of California.

What is it? said Gerry Neugebauer, chief scientist in the project for California's Jet Propulsion Laboratory and director of the Palomar Observatory for the California Institute of Technology.

Stack of Cornell University's Center for Radio Physics and Space Research and a member of the working team "It is in that class, I don't know how the world's planetary scientists would ever begin to describe it."

Then, what is it? What if it is as large as Jupiter and as close to the sun it would be part of the solar system? Conceivably, it could be the 10th planet astronomers have searched for in vain. It also might have to be between a star and our sun but I feel enough.

CHICAGO SUN-TRIBUNE, OCTOBER 16, 1953

'Mystery' body found in space

Washington Post News Service

WASHINGTON—A heavenly body that has been found in the vicinity of the constellation Orion by an astronomer working at the California Institute of Technology.

It is possibly as large as the planet Jupiter and possibly as close to Earth as it would be seen in the night sky.

It is possible that the object that astronomers do not know if it is a planet, a giant comet, a "protostar" that never got hot enough to become a star, a distant galaxy or something else that stars, or a galaxy or something else that stars.

"I don't know what it is," said Gerry Neugebauer, chief scientist for California's Jet Propulsion Laboratory and director of the Palomar Observatory for the California Institute of Technology.

The astronomer team is so sure that it came into being and has never been seen through normal telescopes on Earth to us here. The most interesting observation is that it is a giant, gaseous planet or large as Jupiter and a mass of billions of times that of Earth.

At solar system's edge, giant object is mystery

By Thomas O'Toole

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Giant object mystifies astronomers

By Thomas O'Toole

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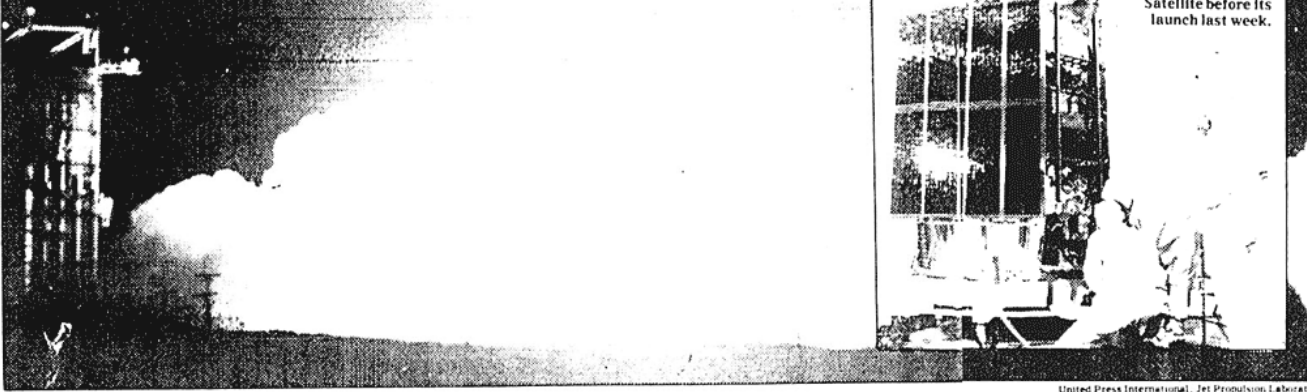
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Ideas & Trends

Continued



U.S. and Dutch technicians preparing the Infrared Astronomical Satellite before its launch last week.

United Press International, Jet Propulsion Laboratory

Clues Get Warm in the Search for Planet X

By JOHN NOBLE WILFORD

SOMETHING out there beyond the farthest reaches of the known solar system seems to be tugging at Uranus and Neptune. Some gravitational force keeps perturbing the two giant planets, causing irregularities in their orbits. The force suggests a presence far away and unseen, a large object that may be the long-sought Planet X.

Evidence assembled in recent years has led several groups of astronomers to renew the search for the 10th planet. They are devoting more time to visual observations with the 200-inch telescope at Mount Palomar in California. They are tracking two Pioneer spacecraft, now approaching the orbit of distant Pluto, to see if variations in their trajectories provide clues to the source of the mysterious force. And they are hoping that a satellite-borne telescope launched last week will detect heat "sig-

natures" from the planet, or whatever it is out there.

The Infrared Astronomical Satellite was boosted into a 560-mile-high polar orbit Tuesday night from Vandenberg Air Force Base, Calif. It represents an \$80-million venture by the United States, Britain and the Netherlands. In the next six or seven months, the telescope is expected to conduct a wide-ranging survey of nearly all the sky, detecting sources not of ordinary light but of infrared radiation, which is invisible to the human eye and largely absorbed by the atmosphere. Scientists thus hope that the new telescope will chart thousands of infrared-emitting objects that have gone undetected — stars, interstellar clouds, asteroids and, with any luck, the object that pulls at Uranus and Neptune.

The last time a serious search of the skies was made it led to the discovery in 1930 of Pluto, the ninth planet. But the story begins more than a century before that, after the discovery of Uranus in 1781 by the English astronomer and musician William Herschel. Until then, the

planetary system seemed to end with Saturn.

As astronomers observed Uranus, noting irregularities in its orbital path, many speculated that they were witnessing the gravitational pull of an unknown planet. So began the first planetary search based on astronomers' predictions, which ended in the 1840's with the discovery of Neptune almost simultaneously by English, French and German astronomers.

But Neptune was not massive enough to account entirely for the orbital behavior of Uranus. Indeed, Neptune itself seemed to be affected by a still more remote planet. In the late 19th century, two American astronomers, William H. Pickering and Percival Lowell, predicted the size and approximate location of the trans-Neptunian body, which Lowell called Planet X.

Years later, Pluto was detected by Clyde W. Tombaugh working at Lowell Observatory in Arizona. Several astronomers, however, suspected it might not be the Planet X of prediction. Subsequent observations proved

them right. Pluto was too small to change the orbits of Uranus and Neptune; the combined mass of Pluto and its recently discovered satellite, Charon, is only one-fifth that of Earth's moon.

Recent calculations by the United States Naval Observatory have confirmed the orbital perturbation exhibited by Uranus and Neptune, which Dr. Thomas C. Van Flandern, an astronomer at the observatory, says could be explained by "a single undiscovered planet." He and a colleague, Dr. Robert Harrington, calculate that the 10th planet should be two to five times more massive than Earth and have a highly elliptical orbit that takes it some 5 billion miles beyond that of Pluto — hardly next-door but still within the gravitational influence of the Sun.

Some astronomers have reacted cautiously to 10th-planet predictions. They remember the long, futile quest for the planet Vulcan inside the orbit of Mercury; Vulcan, it turned out, did not exist. They wonder why such a large object as a 10th planet escaped the exhaustive survey by Mr. Tombaugh, who is sure it is not in the two-thirds of the sky he examined. But according to Dr. Ray T. Reynolds of the Ames Research Center in Mountain View, Calif., other astronomers "are so sure of the 10th planet, they think there's nothing left but to name it."

At a scientific meeting last summer, 10th-planet partisans tended to prevail. Alternative explanations for the outer-planet perturbations were offered. The something out there, some scientists said, might be an unseen black hole or neutron star passing through the Sun's vicinity. Defenders of the 10th planet parried the suggestions. Material falling into the gravitational field of a black hole, the remains of a very massive star after its complete gravitational collapse, should give off detectable X-rays, they noted; no X-rays have been detected. A neutron star, a less massive star that has collapsed to a highly dense state, should affect the courses of comets, they said, yet no such changes have been observed.

More credence was given to the hypothesis that a "brown dwarf" star accounts for the mysterious force. This is the informal name astronomers give to celestial bodies that were not massive enough for their thermonuclear furnaces to ignite; perhaps like the huge planet Jupiter, they just missed being self-illuminating stars.

Most stars are paired, so it is not unreasonable to suggest that the Sun has a dim companion. Moreover, a brown dwarf in the neighborhood might not reflect enough light to be seen far away, said Dr. John Anderson of the Jet Propulsion Laboratory in Pasadena, Calif. Its gravitational forces, however, should produce energy detectable by the Infrared Astronomical Satellite.

Whatever the mysterious force, be it a brown dwarf or a large planet, Dr. Anderson said he was "quite optimistic" that the infrared telescope might find it and that the Pioneer spacecraft could supply an estimate of the object's mass. Of course, no one can be sure that even this discovery would define the outermost boundary of the solar system.



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Brown dwarf discovered entering Solar System, responsible for changing weather patterns

Published on April 1, 2012 - 21:40 UT
- By TWS Staff Reporter
- Edited by TWS Editor



Découverte d'une naine brune entrant dans le système solaire responsable des changements météorologiques

Rare Brown Dwarf Discovered --35 Times Size of Jupiter - Mozilla Firefox

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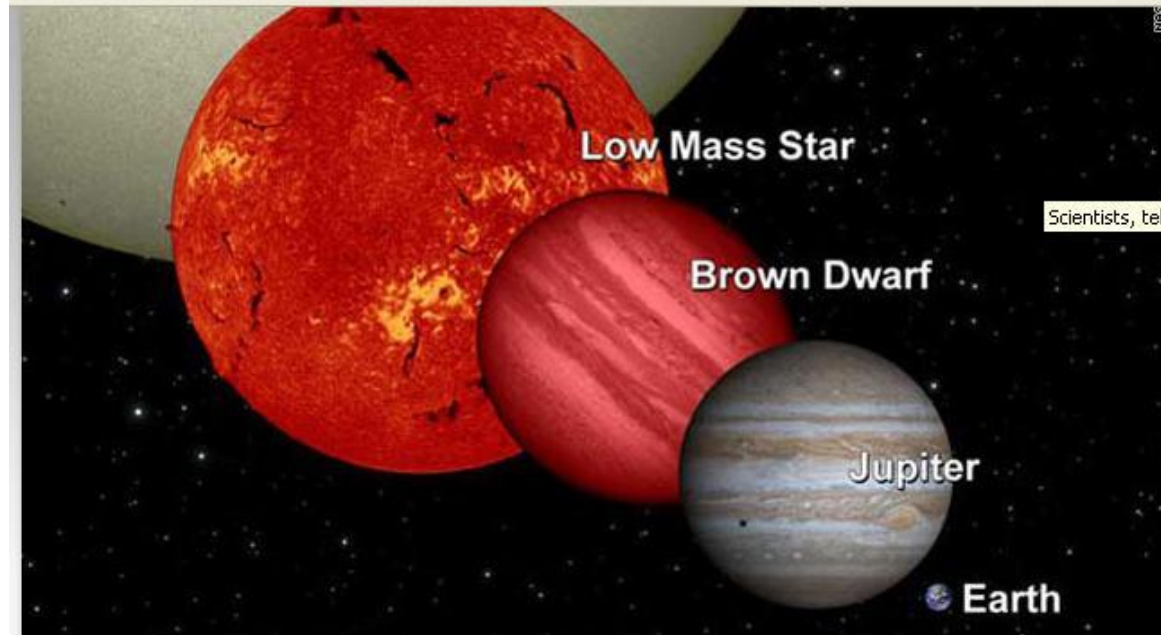
May 10, 2012

Rare Brown Dwarf Discovered --35 Times Size of Jupiter



Roll Over To Play

Découverte d'une naine brune rare -- 35 fois la taille de Jupiter



Low Mass Star

Brown Dwarf

Jupiter

Earth

Some scientists think a brown dwarf or gas giant bigger than Jupiter could be at the outer reaches of the solar system. In this image showing relative size, the white object at the upper left edge represents the sun.

February 15th, 2011

09:03 AM ET

Scientists, telescope hunt massive hidden object in space

You know how you sometimes can sense that something is present even though you can't see it? Well, astronomers are getting that feeling about a giant, hidden object in space.

And when we say giant, we mean GIANT.

Evidence is mounting that either a brown dwarf star or a gas giant planet is

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Scientists, telescope hunt massive hidden object in space

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“Maoists may demonstrate, I cannot go and meet them”

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Planet X, Hercolubus or Nibiru.

Hercolubus Tyche Mass = up to 5,300 Earths

Jupiter Mass = 1,300 Earths

Earth Mass = 6×10^{24} kg

Scientists are just analyzing the data gathered by a NASA space telescope WISE, it shows a giant planet up to four times the mass of Jupiter lurking in the outer dark cloud, the most remote region of the solar system. The orbit of Tyche (Hercolubus) would be 15,000 times farther from the Sun than the Earth's, and 375 times farther than Pluto's.

The first tranche of data to be released in April, and astrophysicists John Matese and Daniel Whitman from the University of Louisiana at Lafayette think it will reveal Tyche (Hercolubus) within two years.

This means that NASA considers impossible to cover up the Hercolubus approaching in two years.

Once Tyche (Hercolubus) has been located, other telescopes could be pointed at it to confirm it.

The International Astronomical Union (IAU) may create a whole new category for Tyche, Professor

Nasa Wise Telescope Discovers Planet Tyche Hercolubus Nibiru X

NASA WISE Telescope shows a Giant Planet next to the Solar System. February 13, 2011. NASA confirms that it is tracking Hercolubus, at the moment scientists call it as Tyche. The NASA Wide-field Infrared Survey Explorer (WISE) telescope is showing a giant planet next to the Solar System. Tyche (Hercolubus) is 4 times bigger than Jupiter and orbit at the outer edge of the Solar System. Scientists are just analyzing the data gathered by a NASA space telescope WISE, it shows a giant planet up to four times...

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Le télescope de la NASA Wise a découvert la planète Tyche Hercolubus Nibiru X

Le télescope de la NASA WISE montre une planète géante près du système solaire.

Le 13 février 2011, la NASA confirme qu'elle recherche Hercolubus, à ce moment les scientifiques la nomment Tyche.

Le télescope de la NASA grand champ Infrarouge Survey Explorer (WISE) montre une planète géante à côté du système solaire.

Tyché (Hercolubus) est 4 fois plus grand que Jupiter et orbite sur le bord extérieur du système solaire. Les scientifiques du système solaire analysent simplement les données recueillies par le NASA WISE télescope spatial, il montre une planète géante jusqu'à quatre ...

Traduction de l'article de la page précédente



Nibiru et ses planètes



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General Relativity and Quantum Cosmology

On the anomalous secular increase of the eccentricity of the orbit of the Moon

Lorenzo Iorio

(Submitted on 1 Feb 2011 (v1), last revised 22 Apr 2011 (this version, v6))

A recent analysis of a Lunar Laser Ranging (LLR) data record spanning 38.7 yr revealed an anomalous increase of the eccentricity of the lunar orbit amounting to $de/dt_{meas} = (9 \pm 3) 10^{-12} \text{ yr}^{-1}$. The present-day models of the dissipative phenomena occurring in the interiors of both the Earth and the Moon are not able to explain it. We examine several dynamical effects, not modeled in the data analysis, in the framework of long-range modified models of gravity and of the standard Newtonian/Einsteinian paradigm. It turns out that none of them can accommodate de/dt_{meas} . Many of them do not even induce long-term changes in e ; other models do, instead, yield such an effect, but the resulting magnitudes are in disagreement with de/dt_{meas} . In particular, the general relativistic gravitomagnetic acceleration of the Moon due to the Earth's angular momentum has the right order of magnitude, but the resulting Lense-Thirring secular effect for the eccentricity vanishes. [A potentially viable Newtonian candidate would be a trans-Plutonian massive object \(Planet X/Nemesis/Tyche\) since it, actually, would affect \$e\$ with a non-vanishing long-term variation.](#) On the other hand, the values for the physical and orbital parameters of such a hypothetical body required to obtain the right order of magnitude for de/dt are completely unrealistic. Moreover, they are in neat disagreement with both the most recent theoretical scenarios envisaging the existence of a distant, planetary-sized body and with the model-independent constraints on them dynamically inferred from planetary motions. Thus, the issue of finding a satisfactory explanation for the anomalous behavior of the Moon's eccentricity remains open.

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Un rapport de l'université Cornell des USA

On the anomalous secular increase of the eccentricity of the orbit of the Moon

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ABSTRACT

A recent analysis of a Lunar Laser Ranging (LLR) data record spanning 38.7 yr revealed an anomalous increase of the eccentricity e of the lunar orbit amounting to $\dot{e}_{\text{meas}} = (9 \pm 3) \times 10^{-12} \text{ yr}^{-1}$. The present-day models of the dissipative phenomena occurring in the interiors of both the Earth and the Moon are not able to explain it. In this paper, we examine several dynamical effects, not modeled in the data analysis, in the framework of long-range modified models of gravity and of the standard Newtonian/Einsteinian paradigm. It turns out that none of them can accommodate \dot{e}_{meas} . Many of them do not even induce long-term changes in e ; other models do, instead, yield such an effect, but the resulting magnitudes are in disagreement with \dot{e}_{meas} . In particular, the general relativistic gravitomagnetic acceleration of the Moon due to the Earth's angular momentum has the right order of magnitude, but the resulting Lense-Thirring secular effect for the eccentricity vanishes. A potentially viable Newtonian candidate would be a trans-Plutonian massive object (Planet X/Nemesis/Tyche) since it, actually, would affect e with a non-vanishing long-term variation. On the other hand, the values for the physical and orbital parameters of such a hypothetical body required to obtain at least the right order of magnitude for \dot{e} are completely unrealistic: suffices it to say that an Earth-sized planet would be at 30 au, while a jovian mass would be at 200 au. Thus, the issue of finding a satisfactory explanation

102.0212v6 [gr-qc] 22 Apr 2011

Un rapport de l'Institut de Recherche (MIUR), à Bari (BA), en Italie



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Confessions d'un agent secret du Vatican

Un article du Nexus (n°51 juillet-août 2007)

L'homme est jésuite, il se présente à Barbato comme étant un familier du Vatican travaillant pour le Saint Siège. D'abord sceptique et méfiant à l'égard de ce contact soit disant « initié », Barbato analyse et vérifie ses références (en se gardant, comme le veut son éthique de journaliste, d'indiquer sa source) : il s'agit bien d'un prêtre jésuite, oeuvrant à la Cité du Vatican. Après quelques échanges par mails, le journaliste italien demande que leur dialogue se poursuive de vive voix. Malgré le danger, vraisemblablement conscient que cette rencontre est préférable vu l'énormité des révélations qu'il s'appête à faire, l'homme du Vatican accepte. Deux rencontres ont donc lieu à Rome, en 2001 (voir interview page 58). Barbato apprend que des dissensions règnent au sein du SIV, un groupe minoritaire désapprouvant la politique conduite à propos de la planète X. À partir de là, il est clair pour Barbato que la démarche du jésuite ne procède pas d'une simple trahison; mais d'une révélation dont l'enjeu est de taille : la survie de notre civilisation.



La « vidéo jésuite »

Avant même leur rencontre à Rome, le contact du Vatican avait fait parvenir à Barbato, en guise de preuve, une bande vidéo - que je nomme la « vidéo jésuite » - destinée à alerter le public. D'une durée d'environ deux minutes, elle évoque l'observation d'un planétoïde couvert d'une atmosphère épaisse (la présumée planète X) se dirigeant vers le système solaire, bien qu'encore en dehors de l'orbite de Neptune. La bande, que j'ai eu plusieurs fois l'occasion de visionner, est assortie de diverses classifications, dont la « Secretum Oméga », le plus haut niveau de secret

Un document du Comité de Recherches aux Affaires Spatiales

A TELESCOPE IN A BOTTLE

IRAS has given astronomers their first detailed survey of the far-infrared sky — in a sense, affording them the opportunity to view the universe anew. What made IRAS' mission particularly challenging, and even more gratifying, was its technological complexity. NASA had never before launched a cryogenically cooled telescope, despite decades of experience with spaceborne observatories.

To keep the project within reason, both technically and financially, responsibility was shared by three nations. The United States designed and built the telescope, provided the Delta launch vehicle, and is processing the data to its final form at the Jet Propulsion Laboratory. The Netherlands Agency for Aerospace Programs (NVR) provided the rest of the 1,020-kg satellite and one of the experiments, then installed the completed telescope prior to launch. At Chilton, England, the U. K. Science and Engineering Research Council (SERC) built the single ground station that controlled the spacecraft and collected its data. These agencies shared IRAS' cost as well, about \$119 million for NASA, \$45 million for NVR, and \$25 million for SERC.

Crucial to IRAS' success was a blanket of superfluid helium that maintained the telescope at 2.4° Kelvin (-455° Fahrenheit) throughout the mission. A temperature this near absolute zero kept the spacecraft's thermal "noise" from blinding the detectors. IRAS' cryogenic Dewar, or vacuum-insulated enclosure, contained 72.3 kg of helium just before the satellite's launch on January 25, 1983 — an amount calculated to chill the telescope for a full seven months.

Once in orbit, however, the spacecraft consumed its helium much more slowly than expected. There was even hope (and a few bets) that the telescope would operate for a full year. But when the last bit of helium evaporated on November 21st the detectors quickly warmed and became useless, ending the mission. Still, the scientific team was elated with IRAS' 10-month performance. "No one thought the Dewar supply would last so long, or that the detectors would be so sensitive," notes Nancy Boggess, the project scientist at NASA.

The telescope itself was an f/9.6 Ritchey-Chretien design with a 57-cm (22½-inch) primary mirror. At the focal plane, 17 rows of infrared detectors and eight star sensors were crowded into half of the 1° field of view. A table on page 4 last month describes all the detectors except the Dutch experiment (a photometer and a low-resolution spectrometer operating from 7 to 24 microns).

Building the IRAS telescope proved a

difficult technical challenge that had its rough moments. E. Kane Casani, who oversaw the fabrication at JPL, says the major problems were related to the supercooled helium. One, of course, was welding the Dewar and its connections together so they didn't leak. Another involved designing a porous, yet leakproof, stainless-steel plug that would dissipate the helium's accumulated heat by allowing the fluid to evaporate slowly.

Some problems were unexpected. The telescope's beryllium optics, made by the Perkin-Elmer Corp. in Danbury, Connecticut, became noticeably pitted during polishing. The mirrors' metallic surfaces may have reacted with the polishing compound, but no one is certain about the cause. Particularly troublesome was achieving an optical figure that would remain accurate near absolute zero. Back at JPL, electronics failed and lenses cracked at the frigid operating temperatures. When the assembled telescope was filled with helium 11 months before launch, the entire 25-micron detector set would not work — one bad detector had shorted out all the rest.

With numerous technical problems awaiting solutions and costs mounting, the project found itself in serious difficulty. IRAS scientist Charles Beichman was worried, as were many others. "Someone should have taken a picture of what the telescope was like eight months before launch," he said after a NASA press conference on November 9th. "When we turned this thing on, I wouldn't have given you a plugged nickel for its chances. It looked as if we were going to have to tear it apart and have a year's delay. That didn't come across at today's happy, success-oriented meeting."

The fact is that IRAS was very successful. By the time its helium supply ran out, the telescope had scanned 95 percent of the entire sky twice and was three-quarters of the way through a third sweep (which would have been completed with two weeks' more helium). Along the way the spacecraft took time to "stare" at many objects or scan them repeatedly, yielding better sensitivity and spatial resolution than the normal survey scans provided.

By the end of this coming summer, the trilateral IRAS team will publish a catalogue of the estimated 200,000-250,000 infrared point sources identified by the satellite. When the mission abruptly ended in November, about five percent of the sky had been seen only once or not at all; since a source must appear on two passes to be considered real, these areas will be excluded from the catalogue.

J. KELLY BEATTY

The first report of such observations involved three radio-loud and two radio-quiet quasars. The former all fall into the generic group known as "blazars" — compact radio sources that exhibit large optical or radio variations over short periods of time. IRAS observations of the blazars' far-infrared emission strengthens the current belief that these objects are powered largely by the synchrotron process.

The radio-quiet examples, on the other hand, seem to have excess emission at 100 microns, which may be coming from the underlying galaxies, presumably spirals, in which the quasars are embedded. This conjecture is supported by evidence, from ground-based studies, that the quasar-galaxy pair also has excess emission at shorter infrared wavelengths. Unfortunately, even though the IRAS data suggest the presence of the quasars' host galaxies, they do not tell us anything new about how the bright infrared glow arises.

Perhaps the most intriguing and fascinating of the IRAS findings are the unidentified point sources. Out of 8,709 sources found in the minisurvey, at least four have no known counterpart — no stars, nebulae, or galaxies. At a November 9, 1983, press conference J. Houck reported that these objects did not change their apparent positions over a period of many hours, so each must lie more than 30 a.u. away. However, there is no reason at present to assume that they lie outside our galaxy, or even outside our solar system. They could, in fact, be distant planets.

Specifically, the observations would fit a Jupiter-size object at a distance of some 570 a.u.; that far from the Sun, its temperature would be only 40° K. Such an object would have an apparent visual magnitude of about 18.3 and would likely have escaped discovery at visible wavelengths. If these IRAS sources are closer, say 30 a.u., they must also be very much smaller. On the other hand, if they do not show a measurable annual parallax during the course of the mission (after analysis, they must be at least 5,000 a.u. away.

But these and other "blank-field" sources could also be fainter or more distant examples of the very infrared-luminous galaxies found in the minisurvey, or perhaps highly evolved stars enshrouded in dense dust shells. The observation would have to be thick enough to hide the stars themselves at visible wavelengths, yet far enough away to maintain the observed low temperatures. At least some of the sources are probably either stars in the early stages of formation or very heavily obscured young stars.

Finally, of course, there is the possibility that IRAS has discovered an entirely new type of celestial object. That's what happened, for example, when the radio, X-ray, and gamma-ray regions of the spectrum were opened, and it might just happen again.

RONALD A. SCHORN

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they are very similar objects.

But RG 0050-2722's brief reign as the faintest known star ended last year when Ronald Probst and James Liebert found that the star LHS 2924 had a peculiar energy distribution and a very low temperature. On this basis they identified it as a black dwarf. It so happened that LHS 2924 was already on a parallax program being conducted by David Monet and Conard Dahn. They reported a preliminary distance for the star of 28 light-years, giving it an absolute magnitude of +20.0. For now, LHS 2924 is the intrinsically faintest star known.

Two other promising systems are Ross 614 and Wolf 424. Both are red dwarf binaries, and both exhibit motions that place them among the young disk population of stars. Ross 614 B has an absolute magnitude of only +16.5. In 1977 Ronald Probst claimed its mass to be $0.07 \pm 0.02 M_{\odot}$ — probably below the critical mass. Wolf 424's two components are intrinsically brighter, at absolute magnitudes +15.0 and +15.2. A 1972 study estimated the masses of Wolf 424 A and Wolf 424 B to be $0.067 \pm 0.015 M_{\odot}$ and $0.064 \pm 0.015 M_{\odot}$, respectively.

When Is a Star Not a Star?

Not very long ago, the difference between a star and a planet was simple — stars twinkle, planets don't. But while this criterion may distinguish Mars from Antares, it is far too simplistic to deal with objects like black dwarfs.

Some astronomers reserve the term "star" for any object fueled by thermonuclear hydrogen fusion — one necessarily above the critical mass of $0.085 M_{\odot}$. It seems unfair, however, to deny stardom to an object that can shine for hundreds of millions of years, even if its source of light is simple gravitational contraction. Although the time during which a subcritical mass object shines is brief compared to the Sun's age, it far exceeds the total lifetime of such stars as Rigel or Betelgeuse.

Banishing subcritical objects from the ranks of stardom creates two other problems. First, it means that if a star like VB 10 is one day found to be subcritical, it has been misclassified a star up to then and should no longer even appear in star catalogs. Second, it also means that in principle you cannot automatically call a shining object beyond the solar system and within the Galaxy a star. Instead, you must first verify that the source of its energy is nuclear fusion — a difficult and daunting task.

Therefore it seems much more reasonable to define a star as an object capable of forming independently of any other star. The smallest star that can form in a nebula is determined by the nebula's density and temperature. The greater the nebula's density and the lower its temperature, the smaller the star that can form. Although the minimum stellar mass is unknown, various astronomers suggest it is roughly $0.01 M_{\odot}$. By our definition of a star, then, an object of Jupiter's mass — $0.001 M_{\odot}$ — could never be a star, since it could not have formed in the absence of the Sun.

Well, then, how large can a planet be? Is there any definite demarcation in mass between stars and planets? Astronomer David Hughes has pointed out that the maximum planetary mass depends not on conditions in the stellar nursery, but on those in the protoplanetary disk surrounding a newborn star. Jupiter's mass of $0.001 M_{\odot}$ may be about tops for a planet, and Hughes argues that objects with masses between the masses of stars and those of planets do not exist.

The ranks of such suspects may soon swell due to two space telescopes: IRAS and the Space Telescope. Launched last year, IRAS surveyed the sky at infrared wavelengths where these cool objects radiate predominantly (see "IRAS and the Infrared Universe," *ASTRONOMY*, March 1984). Scheduled for launch in about two years and concentrating on visible wavelengths, the Space Telescope will penetrate to apparent visual magnitudes of about +26. Based on these instruments' then-projected capabilities, astronomers R. Staller and T. de Jong predicted in 1981 that IRAS would probably fail to find any subcritical mass stars, although the Space Telescope should fare much better — they claimed it should discover an average of 90 per square degree, or almost 4 million over the entire sky.

In order to make such predictions, though, they assumed a total number of very-low-mass stars — and that question is controversial. Because of their intrinsic faintness, very-low-mass stars could abound throughout the Galaxy without being detected. Furthermore, since these stars remain visible for less than a billion years, many have vanished from view by now. If very-low-mass stars have formed at the same rate since the birth of the Milky Way, then every such star we find implies the existence of 10 to 20 others that have already cooled to invisibility. The abundance of suspect stars — VB 10, Ross 614 B, Wolf 424 A and B — within just 20 light-years of the Sun suggests that these stars are numerous.

On the other hand, they could also be quite rare. In 1982 Ronald Probst and Robert O'Connell published results of a search for very-low-mass stars in orbit about nearby white dwarfs. They chose white dwarfs because they're faint to begin with and are especially faint in the red and infrared, where very-low-mass stars shine most. (This helped lower the "noise" in detecting them.) Out of 107 white dwarfs, 15 proved double. Of these 15, only seven had red dwarf secondaries — and none of these red dwarfs had absolute magnitudes fainter than +15, despite the fact the survey would have found any as faint as absolute magnitude +20.7. The negative evidence is not conclusive, however. Perhaps something in the formation of a white dwarf disrupts a small orbiting star, or perhaps these white dwarfs are so old that any subcritical star in orbit about them has cooled too much and faded from view.

Astronomer Shiv Kumar has argued that many of the dark companions detected around nearby stars by Peter van de Kamp and others may be black dwarfs rather than planets, because many of the calculated masses lie above $0.01 M_{\odot}$ (Jupiter's mass, $0.001 M_{\odot}$, is probably close to the upper limit for a planet.) But van de Kamp's results have been seriously questioned by other astronomers (see "The Search for Extrasolar Planets," *ASTRONOMY*, December 1981) and are no longer thought to be reliable. If dark objects are ever found around other stars, orbital eccentricity may provide another method besides mass for distinguishing between black dwarfs and planets. Judging by our solar system, planets tend to have generally circular orbits. Stars in multiple systems, however, often have highly elliptical orbits. So a big

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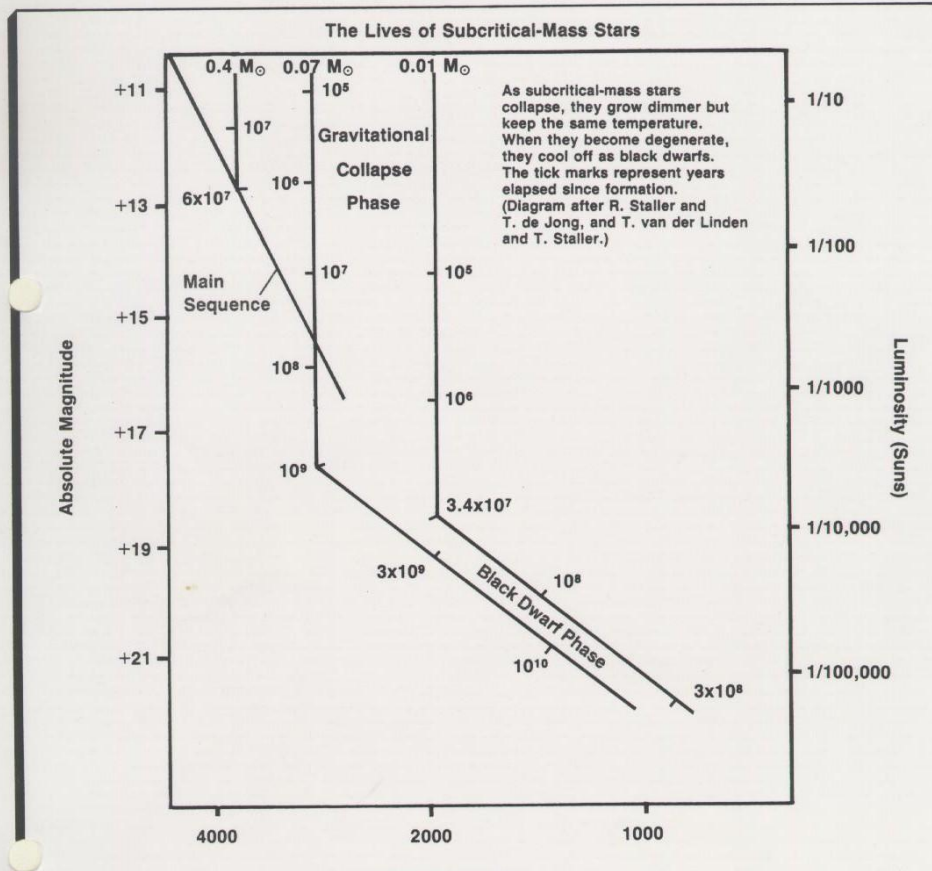
orbital eccentricity, along with a large mass, would argue that a dark companion is a black dwarf. Some astronomers have even speculated that our Sun has a black dwarf companion orbiting far beyond Pluto and perturbing the orbits of Uranus and Neptune. Pluto's mass is now known to be too small to account for the observed irregularities in the motions of Uranus and especially Neptune.)

Subcritical stars also bear on the question of the initial mass function — a term that describes how many stars formed of any given mass. If the initial mass function constantly increases with decreasing mass, then very-low-mass stars are even more abundant than Main Sequence red dwarfs. If, on the other hand, the initial mass function peaks at some value and afterward decreases with decreasing mass,

then very-low-mass stars may be much rarer. A related quantity is the luminosity function — the distribution of stars by absolute magnitude. The luminosity function is small for very bright absolute magnitudes (like our Sun's absolute magnitude of +5), but increases steadily and becomes quite large at the absolute magnitudes of red dwarfs: +9 to +16. The evidence indicates the luminosity function may peak around absolute magnitude +14 and then decline, which suggests that a mass corresponding to this value (roughly $0.15 M_{\odot}$) is characteristic or common for stellar formation. Theoretical studies by astrophysicist Joseph Silk show that $0.2 M_{\odot}$ may indeed be a characteristic size for stars produced in a nebula. But it is also possible that the luminosity function decreases past absolute magnitude +14 simply

4

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Plusieurs astronomes ont spéculé que notre soleil a une naine noire comme compagnon qui est en orbite au-delà de Pluton et qui perturbe les orbites de Uranus et de Neptune.

La masse de Pluton est maintenant reconnue pour être insuffisante pour expliquer les irrégularités des orbites de Uranus et spécialement de Neptune.

because that's where telescopes start to miss intrinsically fainter stars — although many astronomers believe the decline sets in before any instrumental limitations are reached.

Some tantalizing evidence exists, however, that there is far more to the solar neighborhood than meets the eye. Although truly cold, dark stars cannot be seen, their collective gravitational influence can be felt by other stars. By analyzing stellar motions, astronomers can deduce the total mass density in the solar neighborhood of the Galaxy. In 1965 Dutch astronomer Jan Oort did just that and concluded that a typical spherical volume of space with a radius of 10 light-years ought to contain $18 M_{\odot}$ — though this value has a considerable uncertainty. But adding up all the matter we can detect accounts for little more than half that. In the early 1970s, several astronomers believed they had resolved this “missing mass problem” when they discovered that red dwarfs were far more abundant than previously thought and that the standard luminosity function was seriously in error at faint absolute magnitudes. But a few years later, the truth emerged — these astronomers had made a systematic photometric error that caused them to overestimate red dwarf abundances. Thus the luminosity function seems vindicated at least down to absolute magnitudes +14 or +15. This was good news — but it still left the missing mass problem unresolved.

Is the mass in the solar neighborhood abnormally deficient? And if not, where is it? Oort's estimate of $18 M_{\odot}$ per 10 light-year radius is very uncertain, but if it is correct — even roughly — we simply must face the fact that some mass is hiding somewhere in our vicinity. Black holes and neutron stars are possibilities, but they are so rare and exotic that they probably do not affect the overall mass balance of the solar neighborhood very much. Main Sequence red dwarfs still eluding discovery are a more likely possibility, but few astronomers like to pin all their hopes on the long shot that hordes of yet-undiscovered red dwarfs exist nearby. Black dwarfs, on the other hand, could easily make up the deficiency: If there is an average of one black dwarf per two light-year radius, then black dwarfs could account for the solar neighborhood's missing mass.

Aside from such local concerns, the number of black dwarfs in the Milky Way has profound implications for the Galaxy's evolution. Since subcritical mass stars do not burn, the matter locked within them neither changes its form nor escapes into the interstellar medium. More massive stars enrich matter with heavy elements and return it by means of novae, supernovae, and stellar winds to the Galaxy at large. The fewer subcritical stars there are, the faster the galactic material is enriched and returned. In fact, if subcritical stars are very rare, then roughly 40% of the matter in a newborn generation of stars returns to the interstellar medium after a billion years. If, however, very-low-mass stars have as much mass as all others combined, that percentage drops to 20%.

Black dwarfs could affect far more than just the chemical balance of the Galaxy — they could determine the fate of the entire universe. The universe



Cool and nearly invisible, black dwarf stars pose extremely difficult challenges for observational astronomers. Yet if they are as numerous as theory suggests, they have important consequences for the future of our Galaxy — and the universe itself. Painting by Mark Paternostro.

Some tantalizing evidence exists, however, that there is far more to the solar neighborhood than meets the eye. Although truly cold, dark stars cannot be seen, their collective gravitational influence can be felt by other stars. By analyzing stellar motions,

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Quelque évidence que ce soit, cependant, il y a plus à découvrir que nos yeux ne peuvent le permettre

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Les étoiles noires ne peuvent pas être vues, leur influence gravitationnelle collective peut être constatée sur les autres étoiles.

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Les naines noires peuvent compter pour le manque de masse dans le voisinage du système solaire

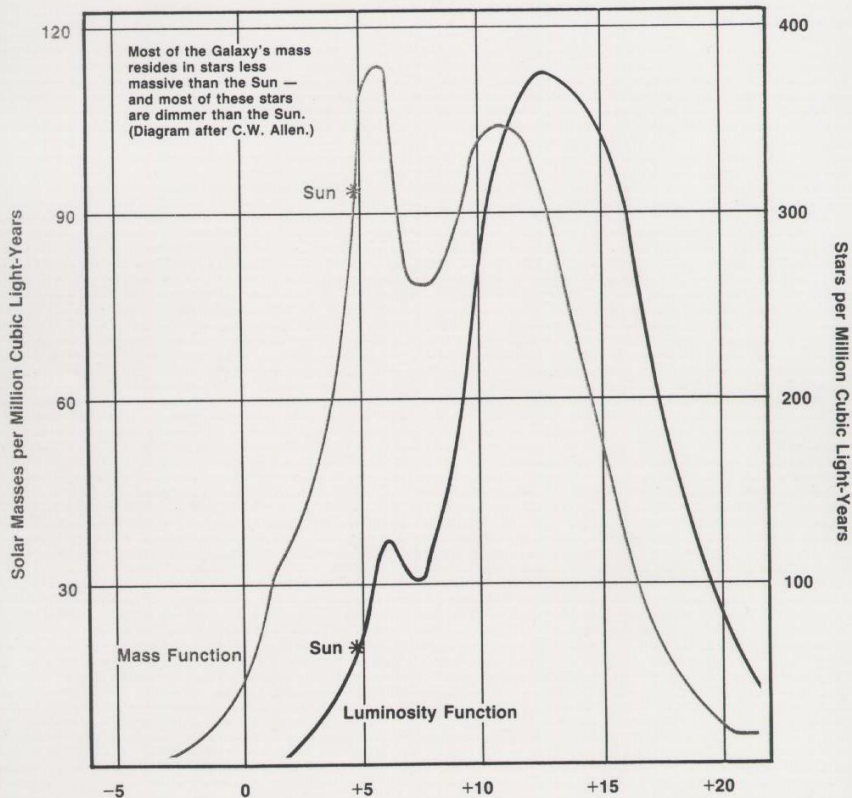
is thought to be expanding from the Big Bang. If it has enough mass, mutual gravitational attraction will reverse the expansion and cause a collapse of the universe. At present, observable matter accounts for only a few percent of the total mass to halt the expansion. Black dwarfs in our Galaxy and others could provide a good deal of the rest, along with black holes, neutron stars, intergalactic gas clouds, and Main Sequence red dwarfs. In fact, because of their low mass, black dwarfs may have preferentially escaped their parent galaxies the way low-weight atoms like hydrogen escaped Earth's atmosphere. Black dwarfs could therefore fill the seemingly empty void between the galaxies. Some astronomers have suggested, furthermore, that the Milky Way's massive corona may consist of many low- and very-low-mass

stars. These little stars, therefore, beset us with enormous mysteries. Stars too small to burn challenge our telescopes to detect them and push observational techniques to the limit. Perhaps the closest such star is only a few light-years away, attended by cold planets immersed in constant darkness and never knowing the difference between night and day. Or is the nearest dark star much closer? Does our Sun have a faithful companion that secretly attends it on its journey around the Galaxy? As always, Nature stands mute, and it is up to us to find out.

Ken Crowell is a graduate student at Harvard University. His most recent feature article was "FG Sagittae: One Piece of the Puzzle," which ran in the October 1983 issue.

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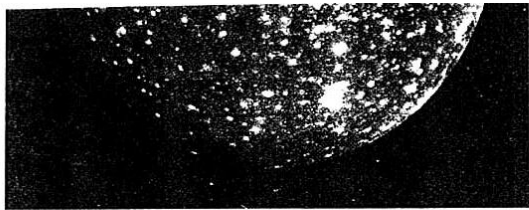


Ou est-ce que la naine noire est plus proche ?

Est-ce que notre soleil a un fidèle compagnon qui l'attend secrètement dans son voyage autour de la galaxie ?

Comme toujours, la nature peut changer, et c'est à nous de trouver.

Astronomy = avril 1984



Icy Callisto, a moon of Jupiter, contains as much as 50 percent frozen water on its crater-pocked surface.

five of the chemical bases for human genes in the Murchison meteorite that fell in Australia in 1969.

Ponnamperuma and other biochemists believe such "precursors of life" are common throughout the universe and could result in the creation of life wherever the appropriate conditions exist.

In addition, data sent back by the Voyager 1 and 2 spacecraft have led researchers to speculate that moons of Jupiter and Saturn may harbor primitive life forms.

Earth is turning up surprising clues about the universe and its relationship to this planet. Particularly intriguing are indications from studies of rocks and bones that a "death star" may have caused catastrophe on Earth millions of years ago and could do so again.

Extinction cycle. Paleontologists say fossil records show a clear pattern of "extinction events" over the past 250 million years, each separated by about 26 to 28 million years.

Geologists, dating the Earth's impact craters, found a similar time pattern with craters forming at roughly the same periods.

Putting together such information, some astronomers theorize the catastrophes may have been caused by a companion star to the sun, approaching every 28 million years.

If the theory is true, the star may return to shatter Earth's biological systems again in 14 million years. Astronomers are trying to identify such a celestial body, searching for a candidate among fainter stars usually ignored.

"We don't know if such a star actually exists," says Richard Muller, a physicist at the University of California, "but it would be the first ever discovered on the basis of geological and biological evidence on Earth."

Such discoveries, and the prospect of more to come, have convinced space scientists they are embarked on the most exciting era yet in understanding the cosmos.

"The most awesome and profound knowledge awaits us," says James Westphal, professor of planetary science at the California Institute of Technology, "and the most exciting will be those things we just haven't even dreamed about yet."

By STANLEY N. WELLBORN

Planet X—Is It Really Out There?

Shrouded from the sun's light, mysteriously tugging at the orbits of Uranus and Neptune, is an unseen force that astronomers suspect may be Planet X—a 10th resident of the Earth's celestial neighborhood.

Last year, the infrared astronomical satellite (IRAS), circling in a polar orbit 560 miles from the Earth, detected heat from an object about 50 billion miles away that is now the subject of intense speculation.

"All I can say is that we don't know what it is yet," says Gerry Neugebauer, director of the Palomar Observatory for the California Institute of Technology. Scientists are hopeful that the one-way journeys of the Pioneer 10 and 11 space probes may help to locate the nameless body.

Some astronomers say the heat-emitting object is an unseen collapsed star or possibly a "brown dwarf"—a protostar that never got hot enough to

become a star. However, a growing number of astronomers insist that the object is a dark, gaseous mass that is slowly evolving into a planet.

For decades, astronomers have noted that the orbits of two huge, distant planets—Neptune and Uranus—deviate slightly from what they should be according to the laws of physics. Gravitational pull from Planet X would explain that deviation.

Moreover, says Neugebauer, "if we can show that our own solar system is still creating planets, we'll know that it's happening around other stars, too."



For Hobart Preston and Larry Waters, back hollows

In Appalachia, Proud Faces Meet Troubled Time

Moonshine and shotgun wars are long in a region known for its independent Today, it's coal and Uncle Sam that bring money—but not enough to erase pov

In the backwoods hills and hollows where most famous family feud took place a century ago and McCoys live in harmony today, puzzled over quarrels attracted so much attention.

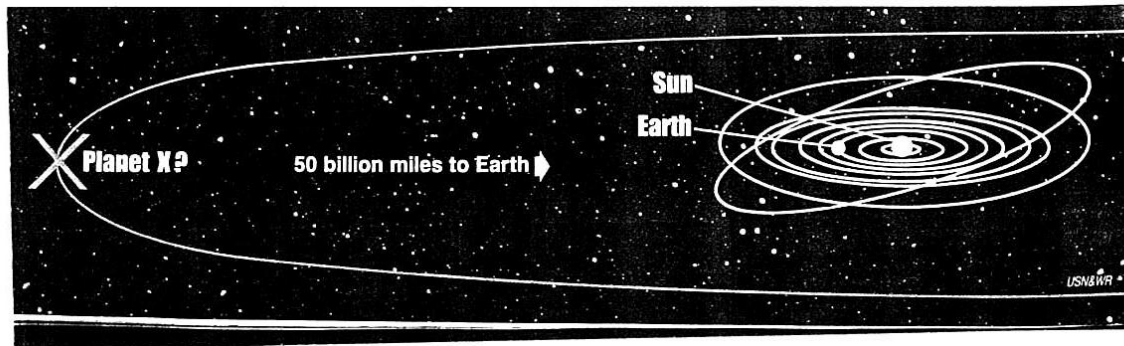
"We sit and laugh about the people who think still going on," remarks David Hatfield, a direct of "Devil Anse" Hatfield, the original clan leader, stovepipe hat and long beard, this modern-day man wears sneakers, Bermuda shorts and a blow-dried

"Some Hatfields work in coal mines, some in stores or sporting-goods stores, others are up hollows," says the 43-year-old Hatfield, a funeral er. "There are Hatfields and McCoys who are even married to each other." For years, he says, there was a Hatfield-McCoy Ford dealership owned by members of both families in nearby Williamson, W.Va.

Where mountain men once exchanged shotgun fire, hunted bears and raccoons and distilled their own moonshine, a four-lane highway now bisects Toler, a contemporary town with a McDonald's, a Sizzler steakhouse, shopping malls and auto dealerships.

That's the sort of scene that Congress had in mind almost 20 years ago when it established the Appalachian Regional Commission to bring this poverty-stricken land into prosperity as part of the Great Society pro-

U.S. NEWS & WORLD REPORT, Sept. 10, 1984



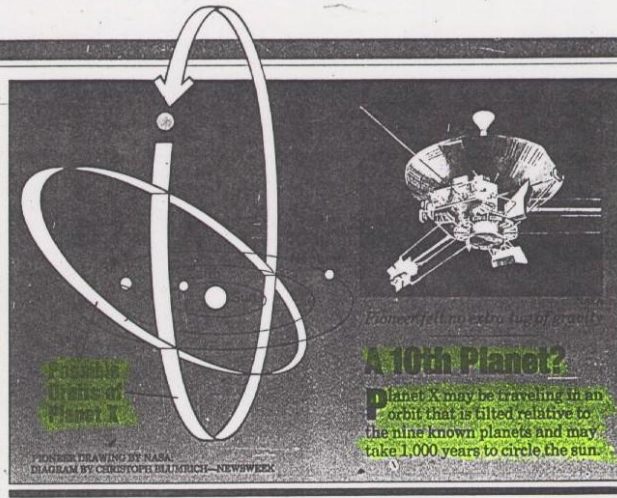
Quelques articles de journaux et de revues

The Search for Planet X

Answering old riddles?

NASA held a press conference at its Ames Research Center in California last week to make a rather strange announcement: an eccentric 10th planet may—or may not—be orbiting the sun. John Anderson, a NASA research scientist who was the principal speaker, has a hunch Planet X is out there, though nowhere near the other nine. If he is right, two of the most intriguing puzzles of space science might be solved: what caused mysterious irregularities in the orbits of Uranus and Neptune during the 19th century? And what killed off the dinosaurs 26 million years ago?

Anderson bases his belief in Planet X on a lack of evidence gleaned from the flights of the two Pioneer spacecraft, now heading into the farthest reaches of the solar system. Back in the last century astronomers noticed that something was causing odd changes in the orbits of Uranus and Neptune. One possible explanation was the tug of gravity from an undetected planet. But if Planet X cruised in a typical orbit, it should have exerted its gravitational tug on the tiny, free-floating Pioneers. That didn't happen.



Why? Anderson and Kenneth Seidelmann, an astronomer at the Naval Observatory in Washington, D.C., searched for an explanation. After double-checking they concluded that the 19th-century records were accurate. They calculated that a distant planet—five times as heavy as Earth—traveling in a very elongated elliptical orbit, possibly perpendicular to the orbits of the known planets, could have caused the changes the 19th-century astronomers saw. By now, however, Planet X would be too far away in its peculiar orbit to affect Neptune or Uranus or to have tugged the Pioneer spacecraft out of their trajec-

tories. Their theory neatly supported observations by astronomers that the orbits of Uranus and Neptune had stopped being perturbed in the early 20th century.

It also matches Daniel Whitmire's explanation for the extinction of the dinosaurs. The University of Southwestern Louisiana astrophysicist envisions a cosmic catastrophe: Planet X's orbit could have passed through the ring of comets surrounding the solar system. When that happened, comets pulled by the planet's gravity could have careened out of their solar orbits, some smashing into the Earth. Dust thrown into the atmosphere would have triggered vast

changes in climate, dooming the dinosaurs. Other astronomers believe it wasn't Planet X but a distant, undiscovered companion star to the sun—sometimes called Nemesis or the "death star"—that sent comets careening toward Earth. There's no more evidence for that, however, than for the existence of Planet X.

Unriddling this puzzle is far from easy. The standard technique is to compare a photograph of a section of the night sky to another taken several weeks later. The stars stay put; but a planet will have moved slightly. The toughest problem, as Whitmire sees it, is that no one really knows where to look. If the question isn't solved sooner, astronomers in the year 2600 might tackle the issue: that's about when Planet X should be causing perturbations in Neptune's orbit again.

WILLIAM D. MARRACHITH
MICHAEL D. CANTOR

MYSTERIOUS PLANET X

I heard that a tenth planet or a star may exist in our outer solar system. Why do astronomers think this and how will they confirm it? *Jorge Esparza, Santa Ana, California*

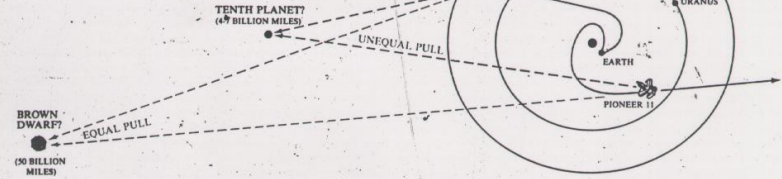
Something must be out there, astronomers believe, because the orbits of Neptune and Uranus deviate slightly from what they should be, according to the laws of physics. A mysterious object—a planet or perhaps a "brown dwarf"—seems to be tugging them off course. Pioneers 10 and 11, American space probes headed beyond the planets, may serve as supersleuths that help identify and locate the source of these gravitational disturbances.

The deviation in the orbits of the two gaseous planets is tiny, only a matter of a few seconds of arc (one second of arc is the width of a penny as it would appear to the naked eye from 2.5 miles). But to astronomers this is a significant amount that needs to be explained. Neptune was discovered in 1846 because of its telltale gravitational pull on Uranus. Now, however, the unexplained deviations of Neptune and Uranus are much smaller than those that tipped off scientists more than a century ago. The new search hasn't been easy.

For a while, Pluto was blamed for the effect. But with the 1978 discovery of the planet's small moon, Charon, Pluto's mass was found to be far too small for it to be the culprit. (Scientists have no direct way to figure out the mass of a planet that has no moon; the calculation is easy if a moon exists.) Pluto's mass is over 100 times less than was estimated; it's only 0.2 percent that of the Earth. Consequently, astronomers have cast their sights farther out.

Can the object be a planet? Or is it a brown dwarf—a star that

As Pioneers 10 and 11 zip out of the solar system, tiny changes in their speeds may reveal just what type of object is now altering the orbits of Neptune and Uranus.



Is it possible to see stars during the day from the bottom of a deep well?

To test this bit of folk wisdom, I once tried it with a number of my students from Ohio State University, substituting a tall smokestack (an idle one) for a deep well. Our cosmic target was the very bright star Vega in the constellation Lyra. This star passes directly overhead at the latitude of Columbus, Ohio, on autumn afternoons.

One clear day, we stationed ourselves at the bottom of the smokestack. The sky looked just as blue and bright from within our "well" as it had from the outside. At the precise moment

didn't quite make it, a body not massive enough to produce the high internal temperatures necessary to ignite its nuclear furnace and thus shine like the sun? Or could it be a neutron star—a star that has gravitationally collapsed into a densely packed, dark remnant of its former luminous self?

The two Pioneers, which are leaving the solar system in opposite directions, still transmit radio signals earthward. If they continue to do so for the next several years, astronomer John Anderson of the Jet Propulsion Laboratory will be able to calculate minute changes in their speeds, down to a fraction of an inch per second. Planet X, which would have to be relatively close by—between 4 and 7 billion miles away—to alter the orbits of Neptune and Uranus, would affect the closer spacecraft (Pioneer 10 in our diagram) but not the other. A brown dwarf or a neutron star—much more massive than a planet—would be and located perhaps 50 billion miles away—would tug evenly on both Pioneers. If the results point to a brown dwarf, it will be the first of these theoretical objects to be identified.

A nearby brown dwarf may be located by another means. Although not hot enough to shine, such a dark star radiates in the infrared region of the electromagnetic spectrum. Planetary scientist Ray Reynolds and his colleagues at NASA Ames Research Center plan to use the Infrared Astronomy Satellite, scheduled for launch next month, to try to find a brown dwarf in our solar system or even farther out in space.

These theories have their critics. Planet X, skeptics say, would have to be as massive as Uranus to alter the paths of it and Neptune. Were that the case, it should long since have been discovered by conventional observations. As for its being a more distant, more massive body, Thomas Van Flandern of the U.S. Naval Observatory argues that the influence of such an object should have produced disturbances in the orbits of other planets—including the Earth.

(I'd like to thank Brenda Alexander of Kansas City, Missouri, and Steve MacDougall of Oakville, Ontario, for their questions on this same topic.)

Vega passed through our field of view, we saw nothing. Small binoculars didn't help; even blindfolding students beforehand to increase light sensitivity proved fruitless.

Perhaps the myth that stars can be seen from the bottom of wells, which has indeed appeared from time to time in literature, started with the Greek philosopher Thales (c. 636-c. 546 B.C.), who is said to have absentmindedly fallen into a deep well. He probably saw stars of a different order of magnitude.

J. Allen Hynke, Ph.D., professor emeritus of astronomy at Northwestern University, asks you to address your cosmic queries to the Astronomy Column, Science Digest, 888 Seventh Avenue, New York, New York 10106.

Diagram by April Leigh Pahl, based on information in Mercury News, San Jose, CA.

FAMILY

The Divorce Game: Slippery Numbers

Is Divorce Court the sequel to the Newlywed Game for half of all married couples? Last week pollster Louis Harris challenged that frequently cited prediction. By dividing Census Bureau figures on divorced people with the number of people who are married, widowed or divorced (the "ever-married," in demographers' parlance), Harris concluded that only one out of eight—not one out

to conclude that roughly half of all marriages are breaking up. This is statistical nonsense."

But others called Harris's one-in-eight prediction nonsense. Census Bureau demographer Arthur Norton contended that no demographer would use simple division to make projections. "Harris's study flies in the face of all the research," he said. It's interpreting the data, it's im-

important. Norton and his colleague Jeanne Moorman expect that 60 percent of ever-married women who were between 30 and 39 in 1985 will divorce at least once while only 24 percent of ever-married women then in their 50s will divorce.

Harris stood by his projections, claiming that the institution of marriage is stronger than people think. Government demographers replied that while there has been a slight decline in divorces recently, the breakup rate for younger people was still high and they don't expect dramatic changes soon.

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13 juillet 1987

Science Digest
novembre 1982

Where Is Planet X?

Mark Littmann, Baltimore, Maryland

URANUS was misbehaving. For 60 years after the planet's discovery by William Herschel in 1781, its orbital motion — first too fast, then too slow — seemed to defy Newton's law of gravity.

Theories were launched and sunk. Vortices between the planets? A flaw in the law of gravity? Some scientists suspected that this irregular motion was caused by an unknown planet beyond Uranus. Independently, John Couch Adams in England and Urbain Le Verrier in France developed a new mathematical analysis to force the perturbed motion of Uranus to reveal the existence, even the position, of an outlying planet. They succeeded brilliantly, but senior astronomers around them ignored or bungled the chance to find a new planet.

Finally, in frustration, Le Verrier contacted Johann Galle, an assistant at the Berlin Observatory. On September 23, 1846, Galle and graduate student Heinrich d'Arrest found the culprit, Neptune, almost exactly where Le Verrier (and Adams) had predicted. Their search took less than an hour. The discovery of Neptune was the most spectacular confirmation of Newton's concept of universal gravitation since the law was published in 1687.

The existence of Neptune explained almost all the problems in the motion of Uranus — almost, but not quite. There remained unexplained "residuals" in the movement of Uranus, even though they were less than 2 percent of what had led Adams and Le Verrier to Neptune. Nevertheless, a few astronomers used these tiny irregularities to postulate the existence of a ninth planet beyond Neptune. Percival Lowell and William H. Pickering, working separately in the United States, found themselves lured ever onward by this tantalizing vision. After a 10-year observational and mathematical search for "Planet X" without success, Lowell died in 1916, in part of disappointment.

However, the observatory Lowell founded in Flagstaff, Arizona, continued to operate. In 1929 the Lowell family provided a 13-inch photographic refractor for a renewed search. To resume the quest, the observatory hired a 22-year-old Kansas farm boy with only a high-school education. Less than a year into the



After discovering Pluto in 1930, Clyde Tombaugh continued combing the sky for additional faint outer planets. By 1943 he had covered essentially the entire region from declination -50° to $+50^\circ$, looking for objects as faint as 16th or 17th magnitude. During this project he spent 7,000 hours examining photographic plates on a blink comparator. Tombaugh now lives in Mesilla Park, New Mexico, and is seen here at the eyepiece of his homemade 16-inch reflector. New Mexico State University photograph by Jack Diem.

search, on February 18, 1930, Clyde Tombaugh found Pluto within 6° of where Lowell and Pickering had predicted it would be. Shades of Adams and Le Verrier!

But there was trouble. Pluto was tiny and showed no disk to telescopes of that day. In fact, it showed no certain disk even when the Palomar 200-inch telescope went into operation. Pluto failed to occult stars it passed. It had to be smaller even than Mercury — the smallest planet in the solar system.

How could such a tiny object cause measurable perturbations in the motion of Uranus, which is never closer to Pluto than a billion miles, more than 10 times the Earth's distance from the Sun? The discovery of Pluto must have been an accident — or, more accurately, the result of Tombaugh's intelligent and extremely careful search.

Then, in 1978, James Christy at the U. S. Naval Observatory discovered that Pluto has a moon. His colleague Robert S. Harrington quickly used that satellite, Charon, to calculate Pluto's mass. The ninth planet had only about 20 percent the

mass of Earth's Moon. But if Pluto wasn't massive enough to cause irregularities in the motion of Uranus and Neptune, what was causing those discrepancies? Had Planet X been missed? Was there yet an undiscovered planet in the solar system?

VAN FLANDERN, HARRINGTON: CATACLYSM AT NEPTUNE

The search for a 10th planet based on the residuals of Uranus and Neptune continues to this day as a part-time activity practiced independently by a small but tenacious group of astronomers who believe that these residuals are an essential clue to the problem.

The unruliness of Uranus and Neptune nagged at U. S. Naval Observatory astronomer Thomas A. Van Flandern. Orbits calculated for Neptune worked briefly, but after 10 years the planet's predicted positions would be noticeably in error. A calculated orbit for Uranus would fit for one whole circuit of that planet but, maddeningly, would fail for the previous or subsequent revolution.

Van Flandern suggested the idea of a

Sky & Telescope
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plained away as systematic errors. Even if the residuals are real, the culprit could be uneven distribution of matter in the outer solar system rather than a planet.

ANDERSON: "NO" MEANS "YES"

In 1987, an unlikely new proponent of a 10th planet attracted much attention. John Anderson at the Jet Propulsion Laboratory was working with NASA's Pioneer 10 and 11 spacecraft. Both craft

are now headed out of the solar system in nearly opposite directions. Pioneer 10 is already beyond the orbits of the planets.

Anderson tracked the departing probes by their radio signals for five years to see if either was deflected from its course by gravity waves moving across the cosmos or by the pull of a trans-Plutonian planet. But neither craft exhibited any sign of unusual perturbation. Anderson therefore concludes that a 10th planet most likely

does exist — a positive conclusion from what seems like negative evidence!

Two years earlier, the interpretation of this data by Anderson was negative: "A three-year analysis of radio tracking data from the Pioneer 10 spacecraft . . . fails to reveal the presence of Planet X."

The data have not changed, but Anderson now believes in the existence of a 10th planet based on the slight unpredictabilities in the motion of the outer planets. The lack of perturbations in the Pioneers therefore provides information about the unseen planet's path.

Planet X, he concludes, was disturbing Uranus and Neptune before and during the 19th century but is now too far away on its highly elliptical and inclined orbit for its gravitational effects to be noticeable on the planets or even on the two tiny, distant Pioneer craft. Its perturbations on the outer planets won't be detected again until about the year 2600.

Anderson puts the orbital period of Planet X at 700 to 1,000 years and its mass at about 5 Earths so that, at perihelion, it could cause the planetary perturbations recognized in the U. S. Naval Observatory data.

For the time being this would-be planet has left us few, if any, clues as to where in the sky to search for it. Anderson hopes that, as Voyager 1 and 2 sail out beyond the planets, their deflections will pin down the location of Planet X.

THE SKY ALREADY SWEEPED

The probable location of a 10th planet is constrained to some extent by the survey work of Tombaugh and others. In 14 years of searching before and after his discovery of Pluto, Tombaugh examined 45 million stars — nearly the entire sky visible from the Lowell Observatory. He is confident that no planet brighter than magnitude 16.5 exists within the 70 percent of the sky he covered. He could have detected a Neptune-size planet some 200 a.u. away. Moreover, Tombaugh concluded, "Other planets like Pluto do not appear to exist out to a distance of 60 astronomical units." Of course, Pluto-like planets may exist farther out, but their tiny perturbations, like Pluto's, would be immeasurably small.

In 1977, Charles T. Kowal began a new systematic search for undiscovered bodies in the solar system using the Palomar 48-inch Schmidt telescope. It has almost 14 times the light-gathering power of the 13-inch astrograph that Tombaugh used to find Pluto. Kowal's seven-year search covered 15° above and below the ecliptic. He found five comets and 15 asteroids, including Chiron, the most distant of all

known asteroids, but not a 10th planet.

He is doubtful that any sizable planet lies within the 30° belt of his survey, but he wouldn't be surprised if a new planet with a high orbital inclination were discovered. Had Pluto been its farthest north or south of the ecliptic (17°.2), it would have been outside his field of search.

Kowal himself made an attempt to calculate the location of a 10th planet and came up with numbers similar to those of Harrington and Van Flandern: a planet several times the mass of Earth and bright enough that Tombaugh should have discovered it. "I spent many years of my life blinking photographic plates," says Kowal, "and I know how easy it is to miss something."

Of his calculations, Kowal notes, "I obtained perfectly reasonable predictions of the orbit of the unknown planet by first using the residuals of Uranus, and then those of Neptune. The only problem is, the two predictions do not agree with each other." He hopes to return to this work soon.

After seven years at the telescope and blink microscope, Kowal formed an indelible conclusion: this kind of search for very faint planets is not feasible. It is too time-consuming and exhausting.

PROBLEMS WITH THE DATA?

For a team of astrodynamists at Caltech's Jet Propulsion Laboratory a decade ago, problems with the motion of Uranus and Neptune switched from theoretical curiosity to practical urgency. Their predictions would have extraordinary consequences. They had the responsibility to position Voyager 2 so that Saturn's gravity would redirect the craft toward Uranus' cloud-tops, rings, and moons. Then they would use that planet for another gravity assist to yet-more-distant Neptune, arriving with such punctuality that Neptune could redirect the spacecraft's course toward its moon Triton. The dynamists had to know with great accuracy how both Uranus and Neptune were moving and exactly where they would be when Voyager 2 flew past them.

E. Myles Standish, Jr., and his JPL colleagues recalculated the orbits of Uranus and Neptune. The ephemeris they created for Uranus very accurately predicted the position of the planet when Voyager 2 arrived. Their ephemeris for Neptune was equally successful when Voyager 2 got there last August. But they achieved these results only by ignoring all astrometric observations of Uranus and Neptune made prior to 1910.

Even though the new ephemeris was based on less than one revolution of

In 1978 James W. Christy

(seated) discovered Pluto's satellite Charon on photographic plates taken with the U. S. Naval Observatory's 61-inch astrometric reflector in Flagstaff, Arizona. This find instantly settled the long controversy over Pluto's mass, and revitalized the search for yet another trans-Neptunian planet. Among those embarking on such a quest is Robert S. Harrington (standing), an expert in solar-system dynamics. U. S. Naval Observatory photograph.



Uranus, the planet was right where it was predicted to be. Standish therefore has no need for a 10th planet. He believes that known sources of systematic error in the 19th-century observations are more significant than many astronomers realize, easily as large as the alleged perturbations being used to predict Planet X. When the early observations are discarded, along with the handful of rediscovery sightings of Uranus and Neptune, and calculations are made on the remaining residuals, the need for a 10th planet falters. What discrepancies remain are small enough to be explained by observational error.

Standish has also detected differences in the way the early observations have been processed by the U. S. Naval Observatory, the Royal Greenwich Observatory, and the Paris Observatory. He would like to reconcile the pre-1910 observations with the modern orbits by going back to the raw data and carefully converting the positions to a common reference system.

There is no way to rule out absolutely the existence of a 10th planet, he notes. But neither is it essential that one exist in order to account for the motions of the planets. And new measuring techniques offer hope of great refinements in our knowledge of precise planetary orbits.

One such method involves the Very Large Array of radio telescopes in Socorro, New Mexico, which has been observing the planets at radio wavelengths since 1984. The VLA's 27 dish antennas, each 82 feet across, move along railroad tracks to separations as great as 23 miles. Arrayed in this way, the dishes can resolve the direction of radio signals from planets with an accuracy of 0.02 arc second, some

20 times better than standard positional measurements in optical wavelengths.

But planets are extended rather than point sources of radio signals, which makes their exact positions difficult to establish. Astronomers at JPL and at NASA's Goddard Space Flight Center are attempting to solve this problem with the help of the most distant cosmic objects of all, quasars. The positions of these radio sources can be nailed down to 0.001 arc second using arrays of very widely separated radio telescopes, and they are much too far away to show any proper motion. Thus quasars can define a truly unchanging coordinate system.

A spacecraft in orbit around a planet could then provide a point-source radio signal much better than the planet's, allowing the body's position to be fixed against the background of quasars. This technique promises planetary positions good to 0.004 arc second, 100 times better than present optical methods. We could know the location of Neptune to within 54 miles, for example, though the planet lies at a distance of 2.8 billion miles.

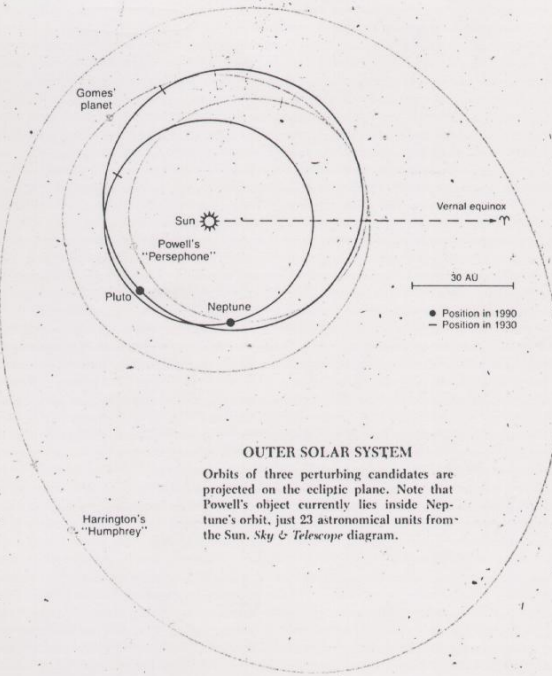
Thinking over his discovery of Pluto and his 14 years of planet searching, Clyde Tombaugh has offered "Ten Special Commandments for a Would-Be Planet Hunter." The final commandment decrees: "Thou shalt not engage in any dissipation, that thy years may be many, for thou shalt need them to finish the job."

For his book *Planets Beyond* (Wiley, 1988), Mark Littmann received the 1989 Science-Writing Award of the American Institute of Physics. He especially thanks E. Myles Standish, Jr., for a helpful critique of this article.

WHERE IS PLANET X?

	Harrington	Powell*	Gomes†	Anderson
Mass (Earth = 1)	4	0.35	0.49	5
Mean Dist. (a.u.)	101.2	34.6	44	79-100
Period (years)	1,019	204	292	700-1,000
Eccentricity	0.411	0.335	0.05	substantial
Inclination (°)	32.4	5.43	low	high
Magnitude	14	14	14-15	?
Probable location	Scorpius	Virgo	Cancer?	?

*Newest calculations (not previously published).
†The "best fit" among many solutions is listed; Gomes' object may lie within 50° of Cancer.



OUTER SOLAR SYSTEM

Orbits of three perturbing candidates are projected on the ecliptic plane. Note that Powell's object currently lies inside Neptune's orbit, just 23 astronomical units from the Sun. *Sky & Telescope* diagram.

ACB13 Cometary Perturbations Suggestive of Planet X

Description. Irregularities in cometary orbits of various kinds, usually undefined in the literature, that are employed to predict the existence and characteristics of Planet X, a body beyond Pluto.

Background. Cometary orbits are notoriously unreliable due not only to nongravitational forces (gas expulsion) but also (possibly) to a dark planetary or defunct stellar body beyond Pluto. Searches for this postulated body or bodies using the telescope have been uniformly negative, but the perturbations of Neptune and many comets, particularly Halley's, seem to tell us that there is something out there. Note that cometary period changes are also dealt with in ACB5.

Data Evaluation. The literature cited in the section rarely specifies the comets used in the analyses or the particular orbital characteristics that have been perturbed. Although this situation is undesirable, the information is probably available somewhere. It seems safe to say that unexplained cometary perturbations really do exist, even though the details are missing in the reports presently on hand. Rating: 2.

Anomaly Evaluation. The anomaly at issue here is not the existence or nonexistence of Planet X but rather the perturbations of the comets. Planet X is just one proposed explanation of these perturbations. The wide ranges of Planet X distances and masses mentioned below assure us that astronomers do not yet have a satisfactory explanation, in Planet X terms, of the cometary perturbations. Since no widely accepted explanation is available, the anomaly rating must be rather high. After all, the perturbations could be due to the inadequacy of the Law of Gravitation or something equally serious. Rating: 2.

Possible Explanations. Planet X or a massive solar companion; nongravitational forces, such as a resisting medium; failure of the Law of Gravitation at great distances.

Similar and Related Phenomena. The residual advances of the planets' perihelions (AHB1, AVB2); changes in cometary periods (ACB5).

Examples

X1. 1931. W. H. Pickering used cometary motions to calculate the orbits of planets P and S, at 75.5 and 48.3 AU, with masses 50 and 5.3 times the earth's, respectively. He relied upon the positions of cometary aphelia to derive the distances. (R6)

X2. 1942. R. S. Richardson, working with the well-known delays in Halley's comet, determined that a delay of half a day could be caused by an earth-sized planet at 36.2 AU. (R1, R6)

X3. 1950. K. Schutte used the orbits of eight periodic comets to predict the existence of a trans-Plutonian planet at 77 AU. (R6)

X4. 1954-1957. H. H. Kritzing refined Schutte's work, using the same eight comets. One of his predictions was of a new planet at 75.1 AU, with magnitude 10. It was looked for but never found. (R6)

X5. 1972. J. Brady. "Using a computer recently to study disturbances in the motion of Halley's Comet since 295 A. D., Joseph Brady of the University of California Law-

rence Livermore Laboratory, predicted that another Planet X should exist beyond the orbit of Pluto. This hypothetical planet would be twice as far from the sun as Neptune and have three times the mass of Saturn or nearly 300 times the mass of Earth---in fact, it would be more massive than all the other planets except Jupiter.

Brady employed the same method used to find Neptune and Pluto. However, instead of looking for irregularities in the orbit of Uranus, he looked for these irregularities in the orbit of Halley's Comet. (This comet regularly returns every 76 years and has been observed since at least 87 B. C.) By carefully choosing just the right mass, position and motion for his new Planet X, Brady found he could reduce the difference between the comet's calculated and observed orbits by 93%. " (R3, R4, R2, R6) Brady's Planet X moved in a highly inclined, retrograde orbit. It was looked for but never found. (R6)

X6. 1975. G. Chebotarev made a mathematical analysis of cometary orbits observed in the prior century, claiming they indicated the presence of Planet Xs at 54 and

100 AU. (R6)

X7. 1978. J. Kirk explored the effect of the postulated companion star to the sun. His conclusion was that the orbits of new comets are so close to being parabolic that there cannot be a solar companion in bound orbit about the sun. (R5)

X8. 1981. P. K. Seidelmann et al. "The authors conclude that some unmodelled force is acting on the outer planets. Observations of six long-period comets, which have had more than one apparition, show that these too are being perturbed by an unmodelled force perpendicular to their orbital plane. The well known non-gravitational force acting on comets has no component in this direction. All these comets have aphelia beyond Neptune.

The cause of the force is unknown. That a Planet X beyond Pluto is exerting a gravitational effect is a possibility but the authors stress that the long and unsuccessful photographic search made by Clyde Tombaugh makes its existence unlikely. If, for example, Planet X was as massive as Jupiter, Tombaugh concluded that he would have found it if it were closer than 470 AU. Also, this phantom 'Planet X' does not seem to have a measurable effect on the orbits of new comets. These comets, which have just been 'bumped' out of the Oort cloud by a passing star, seem to have near perfect parabolic orbits and there is no anisotropy in their major axis distribution. Furthermore, Planet X does not seem to affect the plane of

symmetry of the Solar System. This seems to be dominated by Jupiter." (R7)

X9. 1985. A. H. Delsemme. The orbits of 126 young comets reflect the gravitational influence of a massive body with a mass 10-90 times that of Jupiter, orbiting the sun ever every 5-50 million years. Called Nemesis in the literature of the 1985 period, it is a dark, massive solar companion. (R8)

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- R1. "New Planet May Be Added to the Sun's Family of Nine," *Science News Letter*, 41:361, 1942. (X2)
- R2. "Cometary Evidence of a Planet beyond Pluto," *Science News*, 101:293, 1972. (X5)
- R3. Weaver, Wm. Bruce; "In Search of Planet X," *Astronomy*, 1:17, August 1973. (X5)
- R4. "Does Planet X Exist?" *Sky and Telescope*, 45:22, 1973. (X5)
- R5. Kirk, J.; "On Companions and Comets," *Nature*, 274:667, 1978. (X7)
- R6. Hoyt, William Graves; "More Planets X?" *Planets X and Pluto*, Tucson, 1980. (X1-X6)
- R7. Hughes, David W.; "Planet X: Is It Necessary?" *Nature*, 291:613, 1981. (X8)
- R8. Cowen, Robert C.; "The Mystery of the 'Death Star'," *Baltimore Sun*, August 11, 1985, p. 5E. (X9)

ACB14 Rapid Attrition of the Oort Cloud by Molecular Clouds

Description. The calculated rapid demise of an Oort Cloud of comets due to the sweeping influence of giant molecular clouds from interstellar space. Such molecular clouds are common, and the solar system almost certainly encountered several during its lifetime. Thus, the Oort Cloud, if it ever existed, may have had a very short lifetime.

Data Evaluation. The constituents of giant molecular clouds and their densities are not known with precision. The parameters of the Oort Cloud must be hypothesized, since it cannot be observed directly. The computed attrition rate is therefore only approximate. Rating: 3.

Anomaly Evaluation. The Oort Cloud hypothesis has the cometary shell forming at roughly the same time as the solar system and surviving with minor attrition to the present day. A rapid sweeping action by molecular clouds would cast doubt on the Oort Cloud theory. Rating: 2.

The hunt for Planet X

Is the gravity of an unseen tenth planet pulling Uranus and Neptune off course? Some astronomers think that the answer is yes. But others disagree

Ken Crowell

ASTRONOMERS are looking for an unseen world that they call Planet X. If it exists, it orbits billions of kilometres from the Sun, far beyond the orbits of Uranus, Neptune and Pluto. As it creeps through the frigid outer reaches of the Solar System, Planet X's gravity perturbs the orbits of Uranus and Neptune. And the planet is so far away that sunlight falling on it has barely 0.01 per cent the strength it has on Earth, making the planet colder than any known object in the Solar System.

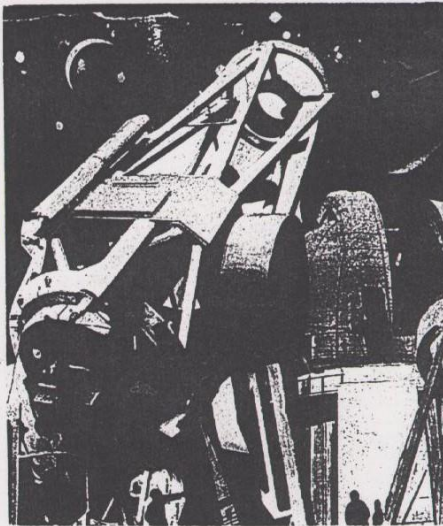
Some astronomers are so sure that Planet X exists that they are searching for it, armed with telescopes, photographic plates, and a machine specifically designed to find unseen planets. By analysing subtle deviations in the motions of Uranus and Neptune from that predicted, these scientists hope to locate Planet X.

Other astronomers think that the search for Planet X is futile. They say that the problems with Uranus and Neptune arise not from Planet X but from observational errors committed during the 19th century. Astronomers must rely on old data to calculate the planets' orbits because Uranus and Neptune take so long to circle the Sun. If the old data are bad, so are the calculated orbits; and if the calculated orbits are bad, then Uranus and Neptune will deviate from them, even without Planet X.

People have wondered whether there are more planets in the outer Solar System ever since the English astronomer William Herschel discovered Uranus in 1781. Herschel found Uranus quite by accident. While he was looking for double stars, he noticed an object in the constellation Gemini that did not look like a star. Herschel thought he had discovered a comet. Instead, the strange body turned out to be a planet twice as distant as Saturn.

After Herschel's discovery, astronomers computed Uranus's orbit. The planet had been observed as early as 1690 by astronomers who mistook it for a star. These old observations helped scientists calculate what should have been a good orbit, because this requires observations spanning a complete revolution. But, over the years, Uranus refused to follow the course the orbit predicted. The planet deviated from the predicted orbit by up to 100 arcseconds (1 arcsecond is 1/3600 of a degree).

In the 1840s, the English astronomer John Couch Adams and the French astronomer Urbain Leverrier speculated independently that a massive planet orbited the Sun beyond Uranus. Its gravity pulled Uranus from the course it would otherwise follow. Adams and Leverrier analysed the motion of Uranus and were able to predict the position of the unknown planet. In 1846, the German astronomers Johann Galle and Heinrich d'Arrest discovered Neptune, precisely where Adams and Leverrier said the planet would be. Neptune is more than a billion kilometres farther away from the Sun than Uranus. Because it has 17 times the mass of Earth, Neptune's gravity can easily pull Uranus off course.



The discovery of Neptune inspired other astronomers to search for unknown planets by looking for small perturbations of the known planets. In the early 1900s, American astronomer Percival Lowell looked closely at the orbit of Uranus, which he thought was still not quite right. He predicted that a ninth planet was perturbing it and estimated that the mass of this unseen planet was 6-7 times that of the Earth.

For many years, Lowell used his observatory in Flagstaff, Arizona, to search for this world, which he called "Planet X". Lowell died in 1916 without having found his Planet X. But in 1929, Lowell Observatory resumed the search, and in 1930 Clyde Tombaugh discovered Pluto, not far from where Lowell had thought it might be.

But Pluto is not Lowell's Planet X; it is far too small to perturb the other planets. Pluto is only 1/500th of the mass of Earth, nowhere near the 6-7 times the mass of the Earth Lowell had assigned to his Planet X. And not only is Pluto far smaller than any other planet, but it is also smaller than several moons, including our own. In fact, Pluto is so tiny that some astronomers do not consider it a genuine planet.

In order to know whether a planet is following the course it should, astronomers must calculate the planet's orbit accurately, taking into account the gravitational influences of all other planets. But computing the orbits of Uranus and Neptune is not easy, because an accurate orbit requires observations that span at least a full orbital period. For planets such as Mars and Jupiter, which circle the Sun in just a few years, this is no problem. But Uranus takes 84 years to circle the Sun, Neptune 165 years. This means that Uranus has circled the Sun

only two-and-a-half times since its discovery in 1781, and Neptune has yet to complete a full orbit since its discovery in 1846. (We cannot use Pluto to test for the existence of Planet X, because no one knows Pluto's orbit accurately enough; it takes 248 years to circle the Sun and so has completed only a quarter of its orbit since its discovery in 1930.)

In principle, Uranus's orbit should be well determined. It

Galileo Galilei observed Neptune in late 1612 and early 1613, nearly two-and-a-half centuries before the planet's discovery. At the time, Galileo was studying the four large moons of Jupiter. In 1979 Steven Albers calculated that Neptune had passed close to Jupiter in 1613, three years after Galileo had discovered the moons. Albers's calculation inspired Charles Kowal of the Space Telescope Science Institute and Stillman



Illustrations by Ken Cox

Drake of the University of Toronto to search through Galileo's notebooks. They found that Galileo had indeed recorded a star where no star exists today. This so-called "star" must have been Neptune.

Galileo's position for Neptune is quite far from the one Neptune should have had according to recent calculations of its orbit. Unfortunately, Galileo probably did not record the planet's position accurately, for he was much more interested in Jupiter and its moons. To him, Neptune was just another star. Few scientists consider Galileo's observations of any help in determining whether Planet X exists.

Of far greater value are two observations that French astronomer Joseph Lalande made in 1795. Lalande was compiling a huge star catalogue and measured accurately the positions of thousands of stars. On 8 May 1795, and again on 10 May 1795, Lalande recorded Neptune.

The positions Lalande measured for Neptune on the two different nights agree with each other, but they differ greatly from where Neptune should have been according to current calculations. Typically, Lalande measured the positions of stars to an accuracy of 2 or 3 arcseconds, yet his observation of Neptune on 8 May is off the predicted position by 12 arcseconds and his observation of 10 May is off by 13 arcseconds.

It is possible that Lalande made a mistake in his calculations, and that he made the same mistake twice. But if his observations are correct, they lend support to the existence of Planet X, which must have been pulling Neptune significantly from its proper course.

Today, Uranus and Neptune are no longer the only objects that scientists can study to detect the influence of Planet X. Four spacecraft, all launched in the 1970s, have now reached the outer Solar System. The first to be launched were Pioneer 10 and Pioneer 11. But these spacecraft provide evidence against Planet X. According to John Anderson of the Jet Propulsion Laboratory in Pasadena, California, the probes are exactly on course. Pioneer 10 flew past Jupiter in 1973, and Pioneer 11 flew past Jupiter in 1974 and Saturn in 1979. The two ships are now heading out of the Solar System in opposite directions, and the steady course of each means there can be no large planet near either.

In the 1970s, the US launched Voyager 1 and Voyager 2.

was observed as early as 1690, so we have data on the planet over more than three and a half revolutions. But there are problems. No single orbit seems to fit all the data. Kenneth Seidelmann of the US Naval Observatory, in Washington DC, can calculate Uranus's orbit only by ignoring the data before 1900. Seidelmann can fit the Uranus data during the most recent orbit, but not during previous ones.

This same problem occurred during the early 1800s, before Neptune was discovered. Astronomers at that time could not reconcile all the Uranus data with a single orbit, so they threw out the oldest data in order to compute the planet's path. The reason for the trouble then was that Neptune was pulling Uranus off course.

Galileo recorded Neptune

Neptune, once the source of Uranus's difficulties, is now having problems itself. Theorists can make the data accumulated since the planet's discovery fit a single orbit. But about ten years after scientists compute an orbit, Neptune begins to deviate from it. Because Neptune has not yet completed an orbit since its discovery in 1846, the problem may simply be that we have not yet determined its orbit accurately. But Neptune has completed 88 per cent of an orbit, and Seidelmann considers it surprising that, with so much data, Neptune still runs off course.

Prior to Neptune's discovery, two astronomers observed the planet without realising it. The positions they recorded for Neptune give us vital data on the planet over more than a full orbit and, therefore, may bolster the case for Planet X.



Voyager 1 flew past Jupiter in 1979 and Saturn in 1980; Voyager 2 flew past Jupiter in 1979, Saturn in 1981, Uranus in 1986 and Neptune in 1989. Unfortunately, both spacecraft are travelling in the same direction as Pioneer 11, so they probably will not provide any additional information on Planet X.

Because the Pioneer spacecraft are travelling unperturbed, the case for Planet X rests entirely on the deviations in the motions of Uranus and Neptune. Are they real or do they result from observational error? The deviations are tiny. Except for Lalande's observations of Neptune in 1795, the deviations in the motions of Uranus and Neptune are less than 1 arcsecond. In comparison, the deviations in the orbit of Uranus before Neptune was discovered were as high as 100 arcseconds.

Scientists interpret the deviations in different ways. Despite the small size of the deviations, Seidelmann believes that they are probably real and do not result from observational error. In his view, Planet X is a good explanation for the problems with Uranus and Neptune.

On the other hand, E. Myles Standish, Jr., of the Jet Propulsion Laboratory in Pasadena, California, thinks the deviations are the result of error. In particular, Standish says that the data before 1910 are faulty. It was only in 1910 that astronomers began to use micrometers to measure the positions of Uranus and Neptune. A micrometer is a device that gives a more accurate measure of a planet's position.

Is the law of gravity incorrect?

Standish believes that there is no evidence for Planet X. He says that in the case of Uranus, if one considers only the data since 1910—which span a complete revolution—there is no problem with the planet's motion. In the case of Neptune, the observations since 1910 cover only half a revolution. Therefore, it is impossible to compute an accurate orbit for the planet. Standish believes this is why Neptune runs away from its predicted course: simply because its orbit is not well determined. Furthermore, because the orbit is not well-known, we do not really know where Neptune should have been in 1795, when Lalande observed the planet. Lalande's observations of Neptune differ from the prediction not because he was wrong but because the prediction is.

If the deviations are real, however, Planet X is quite the best explanation for them, though not the only one. The problem could be that our knowledge of the law of gravity is not quite correct. Few astronomers are willing to consider such an extreme possibility, but we have been wrong before. At the turn of the century, the planet Mercury was off course. Astronomers thought a planet named Vulcan circled even closer to the Sun and pulled Mercury off its predicted path. Some astronomers even claimed to have seen Vulcan.



But Vulcan does not exist. The problem with Mercury was that astronomers did not then know about Einstein's general theory of relativity, a modification of Newton's law of gravity. Today, it is possible, albeit unlikely, that Uranus and Neptune are off course simply because the law of gravity we use in computing their orbits is slightly defective.

No one can rule out problems with the data. But the deviations in the motions of Uranus and Neptune, if real, strongly hint that there is a massive planet in the outer Solar System. The only way to know for sure, of course, is to find Planet X.

The first search for a planet beyond Pluto began in 1930. After he found Pluto, Tombaugh continued to hunt for distant planets, starting, in fact, with the photographic plate on which he had discovered Pluto. Tombaugh searched for far-off planets until 1943, scrutinising most of the sky that is visible from Lowell Observatory in Arizona. He found asteroids, star clusters, galaxies, and a comet, but no new planets.

From 1976 to 1985, Charles Kowal conducted another search, examining the sky for comets, asteroids, and Planet X. Kowal covered less sky than Tombaugh but looked at much fainter objects. In November 1977, Kowal discovered Chiron, an asteroid-turned-comet, between the orbits of Saturn and Uranus ("The changing face of Chiron", *New Scientist*, 25 August). But with a diameter of only 200 kilometres, Chiron was certainly no Planet X.

More recently, Robert Harrington of the US Naval Observatory has led the search. Although he admits that the deviations in the motions of Uranus and Neptune could be due to observational error, Harrington has nonetheless used those deviations in an attempt to locate Planet X. He believes this planet has a mass between three and five times that of the Earth, making Planet X bigger than Earth but smaller than Uranus and Neptune.

The planet Harrington expects to find is a distant one, with an average distance of 15 billion kilometres from the Sun. By comparison, the average distances of Neptune and Pluto are 4.5 billion kilometres and 5.9 billion kilometres respectively. Harrington's Planet X is so far from the Sun that it takes a thousand years to make a single orbit.

The distance of Planet X varies considerably, because its orbit is quite elongated. At its closest, Planet X comes within 9 billion kilometres of the Sun; at its farthest, it recedes to 21 billion kilometres. According to Harrington, Planet X reached its closest point in the late 1700s and is now heading away from us. Harrington's calculations also indicate the planet has an orbit which is inclined at about 30 degrees to the plane of the Solar System. Harrington believes his planet lies in the southern sky. His best guess is that Planet X is in the constellation Centaurus, which is near the Southern Cross.

At Black Birch observatory in New Zealand, Robert Hindley is exposing photographic plates of the area in and around Centaurus. He then ships the plates to Washington, where Harrington examines them on an instrument called a blink comparator. This machine holds two plates of the same region of the sky taken on two different nights and alternates the view of them. Stars, which are fixed, remain steady as the plates alternate, but a planet, which moves slightly from night to night, would jump back and forth from one plate to the

other. Tombaugh used a blink comparator to find Pluto in 1930, and Kowal used one to find Chiron in 1977.

Although Harrington acknowledges that the deviations in Uranus and Neptune could be spurious, he is not worried about the negative results from the Pioneer spacecraft. Neither Pioneer 10 nor Pioneer 11 travelled near Harrington's Planet X, so neither should feel its gravitational pull. In fact, Harrington predicted negative results from the Pioneer data, even before it was analysed. Harrington does take Tombaugh's extensive search seriously, however. According to his calculations, Planet X was too far south in 1930 for Tombaugh to have spotted it from Arizona.

In addition to causing the deviations in the motions of Uranus and Neptune, Planet X may explain the odd orbits of Neptune's satellites and also of Pluto. Triton and Nereid, two of Neptune's moons, have strange orbits. Though it is a large moon, Triton circles Neptune backward in a decaying orbit. Nereid orbits Neptune in the correct direction but follows an extremely elongated path.

Pluto also has a strange orbit. Its distance from the Sun varies so much that at times—for instance, today—Pluto lies closer to the Sun than Neptune does. At other times, Pluto is billions of kilometres farther from the Sun than Neptune. Furthermore, Pluto's orbit is inclined at 17 degrees to the plane of the Solar System.

Harrington believes that long ago, his Planet X may have collided with Neptune. At that time, Triton, Nereid, and Pluto were all satellites revolving around Neptune in normal, circular orbits. Planet X reversed Triton's orbit, stretched out Nereid's orbit, and kicked Pluto away from Neptune.

In the late 1970s, Harrington and Thomas van Flinders carried out computer simulations to see what characteristics an intruder planet might need in order to account for the present orbits of Triton, Nereid, and Pluto. Harrington and van Flinders found that the planet would have to be a few times the mass of the Earth and have an elongated orbit—in other words, it would be a lot like Harrington's Planet X.

Did planet X collide with Neptune?

Since 1988, when Harrington published his prediction for Planet X's location, two other predictions have appeared. These predicted planets differ both from Harrington's and from each other. Conley Powell of Teledyne-Brown Engineering in Huntsville, Alabama, has analysed the motion of Uranus. He believes Planet X is in the constellation of Virgo. Powell's planet is smaller and closer than Harrington's. He puts its mass at less than the Earth's and gives it a distance similar to Pluto's. Meanwhile, Brazilian astronomers Rodney Gomes and Sylvio Ferraz-Mello believe a more distant planet may lie in the constellations of Cancer or Gemini.

The two predicted planets lie farther north than Harrington's. So if they exist, Tombaugh should have found them. In fact, all three planets—including Harrington's—are brighter than Pluto was at the time of its discovery. This convinces some astronomers that none of these worlds really exist. If they did, they would have been found long ago. Furthermore, Standish points out that the three different predictions differ greatly from one another, even though they arise from the same data. That, says Standish, is proof that the data—even if correct—cannot be used to locate Planet X.

Nevertheless, the search will continue. Until Uranus and Neptune behave themselves, Seidelmann sees no reason to give up on Planet X. And Harrington has vowed to continue the search as long as he can come up with some idea as to where the planet is.

Ken Croswell received his doctorate in astronomy from Harvard University and has written for *Astronomy*, *Astronomy Now*, and *Time-Life Books*.

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PLANET X / NEMESIS

result of a quest initiated because of observed irregularities in the orbits of Uranus and Neptune. Astronomers had believed for some time that the gravitational influence of an undetected planet was responsible for the perturbations, and with Tombaugh's find, the culprit seemed to have been apprehended. But by the late 1970s, improved estimates of Pluto's mass had revealed that it was far too small to disturb its giant neighbors, and scientists began to suspect that lurking somewhere beyond the ninth planet was a tenth—known, appropriately, as Planet X. A new generation of planet hunters took up the challenge. "I wish 'em luck," said octogenarian Tombaugh in 1988. "They're in for a lot of hard work."

Two of the leading workers are Robert Harrington and Kenneth Seidelmann, both of the U.S. Naval Observatory in Washington, D.C. Much of their energy has gone into figuring out just where to look, with computers playing a major role. Seidelmann's main contribution is to determine as accurately as possible the differences between the predicted and actual locations of Uranus and Neptune, known as residuals. He does so by comparing the latest sightings of the two planets with a computer simulation of their orbits based on observational data up to 1978. The measured discrepancies become the basis for more laborious rounds of modeling overseen by Harrington. Employing a program that simulates a ten-planet Solar System, Harrington plugs in different values for the mass, distance, and orbit of the unknown Planet X to see which will produce the observed effects on Uranus and Neptune. By the end of the 1980s, the computer had run through more than a third of a million simulations and come up with fewer than 200 possibilities.

The numbers seem to indicate that Planet X should currently be somewhere in a small patch of the southern sky near the constellation Centaurus, but searches of the area have so far turned up nothing. Some astronomers doubt they ever will. "Most of it's a bunch of nonsense," says Brian Marsden of the Harvard-Smithsonian Center for Astrophysics. "It is more likely that the residuals have some other explanation in some kind of observational error or instrumental error or systematic error. I think those have to be considered first before we jump to wild conclusions about distant planets." However, until any such errors can be brought to light, Planet X will remain a plausible albeit elusive quarry.

NEMESIS

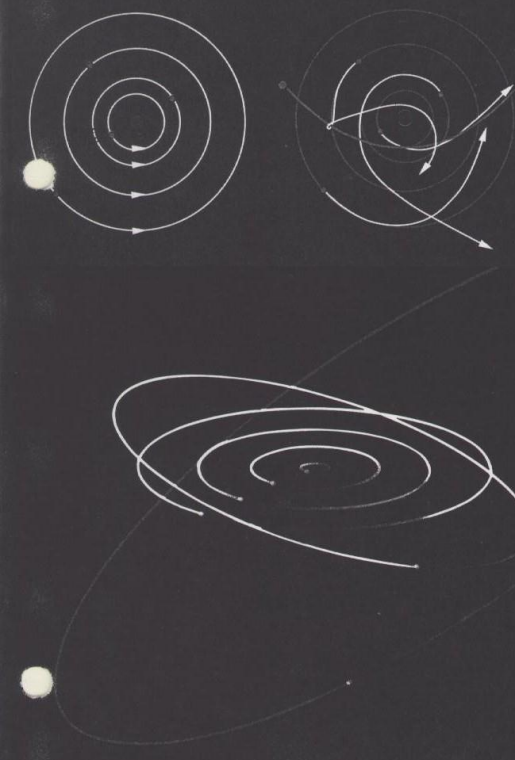
A few theorists think there may even be another member of the Solar System, far beyond Planet X—and that it may be a killer. Fossil records show that about 65 million years ago, more than two-thirds of the species living on Earth, including all the dinosaurs, simply disappeared. In 1979, the late physicist Luis Alvarez and his son Walter, a geologist, proposed that the disaster occurred when a small asteroid or comet hit Earth, throwing a thick pall of dust into the upper atmosphere and cutting off sunlight for several years; most plants would have died within months, disrupting the food chain and leading to the mass extinctions. Although the theory created a storm of

THE CASE FOR PLANET X

For more than half a century—and with varying degrees of intensity—some astronomers have proposed the existence of a tenth planet. Known as Planet X, the unseen world is invoked to explain certain anomalies in the behavior of Uranus, whose calculated orbit works for one circuit but not the next, and Neptune, whose predicted positions are noticeably in error after several years. Planet X, if it exists, might also explain the odd orbital dynamics of Neptune's moons Triton

and Nereid, and the unexpected size and makeup of Pluto, which is so much smaller and rockier than its huge, gaseous neighbors.

The hunt for Planet X—based on calculations of its presumed mass and orbit—requires painstaking searches of designated patches of sky. In 1846 and again in 1930, such efforts paid off in the discoveries of Neptune and Pluto. Similar dedication may one day turn up a body that so far lives only in theory.



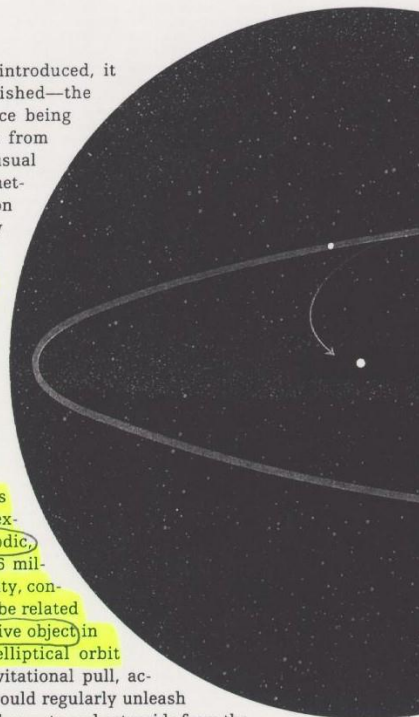
The fourth moon. One scenario to account for the dynamics of the outer Solar System hypothesizes that Neptune once had four satellites—until Planet X (red) plowed through the system. The gravitational effects of its passage sent Triton into a backward circuit around Neptune, stretched Nereid's orbit out to six million miles, and knocked Pluto into an inclined and elliptical path around the Sun. Neptune's erstwhile fourth moon was captured by the intruder.

The first step. To find Planet X, scientists must first calculate its presumed mass and orbit. In the Solar System shown here, Planet X has a mass between two and five times that of Earth and travels in an orbit even more inclined and elliptical than Pluto's. At the farthest point in its orbit, Planet X would be 100 astronomical units from the Sun (or 100 times the distance from the Sun to Earth) and would take from 350 to 1,000 years to complete one circuit.

controversy when first introduced, it now seems well established—the most convincing evidence being that sedimentary layers from that epoch contain an unusual abundance of iridium, a metal that is otherwise rare on Earth—but is relatively common in meteorites.

But what caused the asteroid impact in the first place? Was it just a random event in the violent history of the Solar System, or was it (part of a pattern)? Through more recent, and more detailed, statistical analysis of the fossil record, geologists have found that mass extinctions seem to be periodic, occurring about every 26 million years. Such periodicity, concluded some, could only be related to the (passage of a massive object) in a far-flung, extremely elliptical orbit around the Sun. Its gravitational pull, according to this theory, would regularly unleash a hail of potentially lethal comets and asteroids from the Oort cloud, a collection of frozen chunks of matter that astronomers believe encapsulates the Solar System.

The hypothetical body—(known as Nemesis, or the Death Star)—has drawn an even larger group of detractors than Planet X. For one thing, though predicted to be of stellar proportions, it would have to be very dim and cold to have escaped detection by both optical and infrared telescopes. And periodic extinctions have at least one other possible explanation: The entire Solar System is thought to oscillate up and down within the Milky Way, passing every 30 million years or so through the galactic plane, where clouds of interstellar dust and gas could send Oort cloud comets flying, or higher levels of cosmic radiation could directly affect Earth's climate. Even those who think Nemesis exists admit that they have no other evidence beyond the extinction pattern, since Nemesis would currently be too far away to have any measurable effect on planetary behavior. So while Harrington and other Planet X hunters have been able to improve their chances with new data about



80% OF THE
STARS IN OUR GALAXY
ARE BINARY! (65)

The missing mate. Another hypothetical body, put forward to explain recurring mass extinctions on Earth, is known as Nemesis. This dark stellar companion to the Sun is theorized to be no more than .08 solar masses, with an orbit (red) that takes it out to 170,000 astronomical units, or about three-fifths the distance to the nearest known stars. But roughly every 26 million years, Nemesis returns to the Sun's neighborhood, passing en route through the Oort cloud—a huge sphere of cometary material, left over from the birth of the Solar System—and sending a rain of comets (arrow) toward the inner planets. The resulting meteoritic bombardment might have had catastrophic effects on Earth's climate and life forms.

the orbits of the outer planets, Nemesis advocates can do nothing to narrow their search. The reasons for looking are too few and the places to look too numerous for Nemesis to have stirred much serious interest among members of the astronomical community.

INVISIBLE COMPANIONS

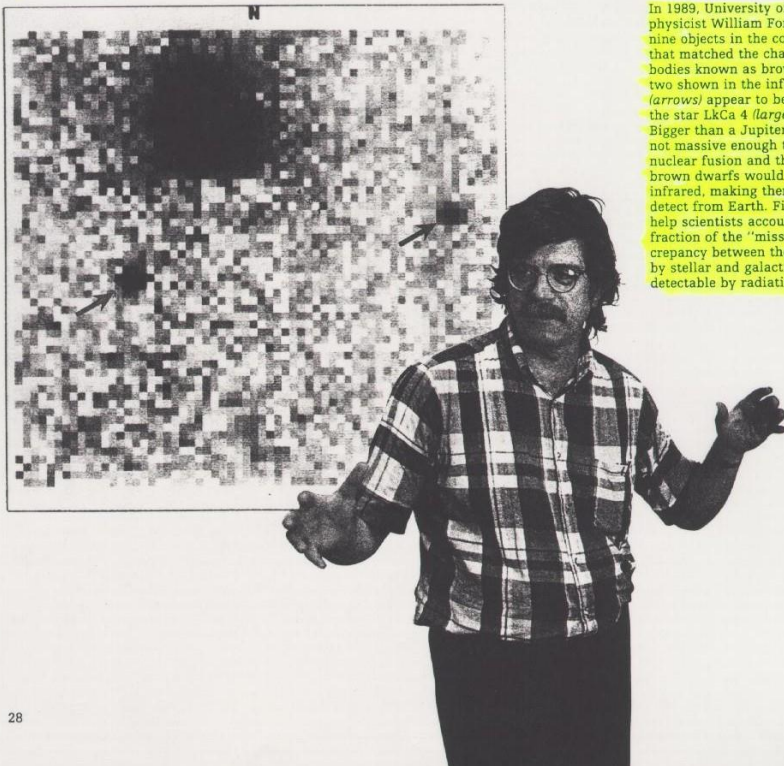
Despite the lack of hard evidence, Nemesis supporters are somewhat encouraged by the fact that companionless stars such as the Sun are relatively rare in the galaxy. About 80 percent of the stars visible in the Milky Way appear to be part of double, triple, or even quadruple star systems—most likely a consequence of the manner in which stars are born. Under certain conditions, such as the passage of a shock wave from a nearby supernova explosion, vast clouds of gas and dust in the spiral arms of galaxies may collapse inward upon themselves, creating regions of high density, pressure, and temperature. As the contraction proceeds, the cloud, or nebula, begins to fragment, and these dense regions form protostars—concentrations of mass whose gravity continues to pull in more dust and gas from the nebula's remnants. Eventually, pressure and temperature become high enough within these protostars to generate fusion reactions, and the newborn stars begin to shine. But before the nuclear furnaces get going, protostars themselves may fragment, the separate pieces typically evolving into stars that are almost certain to be locked in an orbital relationship throughout their history.

Of course, if the Sun does have a companion, it cannot be an identical twin or even an undersize sibling, whose light would be easily detected. One intriguing possibility is that Nemesis could be a strange and still-controversial celestial character known as a brown dwarf, an object that falls somewhere between planet and star. According to standard theories, planets form in a way that is different from the evolution of stars, accreting from small clumps of leftover dust and gas in a disk surrounding a protostar or newborn star. Their initial buildup results mostly from collisions with other bits and pieces in the disk, not through a collapse process or because of conditions of heightened pressure and temperature. Consequently, although they can grow quite large, they can never accumulate enough mass to initiate fusion reactions and become stars. But the theories also allow for another scenario: Some protostars, or perhaps protostar fragments, may never gather sufficient mass to ignite. Such a body would begin its life as a star does, yet, like a planet, would emit little energy of its own. It would be, by its popular moniker, a brown dwarf.

Brown dwarfs, if they exist, would satisfy theorists in at least two regards. For starters, they would fill a gap in the observed sequence of sizes of celestial objects. The largest known planet, Jupiter, has just one-tenth of one percent of the mass of the Sun, a medium-size star. Calculations indicate that the smallest stars require at least eight percent of a solar mass, or eighty Jupiters, to sustain fusion, and that planets could feasibly be as much as ten times larger than Jupiter. Brown dwarfs would cover the ground in between. They

might also help solve the enduring cosmological riddle of the universe's missing mass. Measurements of the gravitational forces at work within galaxies suggest that they should contain as much as ten times more matter than can be accounted for by observation. Proposers of brown dwarfs have reason to believe they should be common in the universe. A census of the skies reveals that very bright, very massive stars are relatively rare, but as mass and luminosity decline, the population increases. By extension, bodies with the postulated characteristics of brown dwarfs ought to be as common as grains of sand on a beach. The total bulk of so many brown dwarfs might be enough to account for the missing mass.

Most scientists doubt the existence of a brown dwarf as a companion to the Sun, but several teams of investigators are hunting for them in the vicinity of other stars. Because brown dwarfs give off little or no visible light, the searchers have had to come up with ingenious methods for detecting their presence. A dark body orbiting a visible star ought to betray itself by creating



In 1989, University of Rochester astro-physicist William Forrest (below) found nine objects in the constellation Taurus, that matched the characteristics of bodies known as brown dwarfs. The two shown in the infrared image at left (arrows) appear to be associated with the star LkCa 4 (large shape at top). Bigger than a Jupiter-size planet, but not massive enough to have triggered nuclear fusion and thus become a star, brown dwarfs would radiate in the infrared, making them very difficult to detect from Earth. Finding them could help scientists account for a significant fraction of the "missing mass"—the discrepancy between the mass indicated by stellar and galactic motions and the detectable by radiation.

a slight wobble in the motion of its bright companion, which would be revealed by a periodic shift in the star's spectrum. A group of Canadian astronomers looking for such spectral shifts with equipment designed to detect extremely minute variations announced in 1987 that they had found evidence for the existence of "low-mass companions" to at least two nearby stars and perhaps as many as seven. Bruce Campbell, speaking for the team, cautioned that they had determined nothing more than the probable masses of the unseen objects, which were between one and ten times that of Jupiter. The news, while exciting for its suggestion that planetary systems may be quite common, was discouraging for brown dwarf aficionados: Bodies of such mass were too small, and objects on the scale of brown dwarfs, which would create larger spectral shifts, ought to have been easier to spot. Having failed to detect any bodies in the required size range, Campbell was ready to rule out brown dwarfs entirely.

HOPEFUL SIGNS

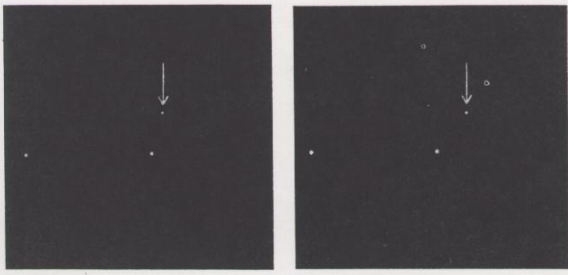
Others questioned such a categorical conclusion. Eliminating an entire class of objects on the basis of a single set of observations seemed premature to some astronomers, and within months of the Canadians' announcement, two observers from the University of Hawaii reported that they had discovered something with at least one of the characteristics of a brown dwarf. Searching for infrared emissions—that is, levels of heat too weak to cause visible radiation—from bodies orbiting small stars, Benjamin Zuckerman and Eric Becklin found a clear-cut signal near the star Gliese 29-38. "It sticks out like a sore thumb," said Zuckerman. The object's temperature closely matched predictions for the thermal output of a brown dwarf, but Zuckerman remained cautious. "We don't know that we've seen a brown dwarf," he noted. "I hope we have. But no matter what it is, we've definitely seen something interesting that we have to understand."

Observations made by several other groups of astronomers in 1988 and 1989 seemed to hint at still more brown dwarfs, but there was enough ambiguity in the data to enable skeptics to pick holes in the claims. Many of the candidates, for example, fell very close to the borderline between brown dwarf and star in terms of their temperature. Although the objects under scrutiny were apparently too cool to be stars, only a minor adjustment to the theoretical minimum stellar temperature would suffice for them to be classified as low-mass stars. Many astronomers felt safer broadening the definition of a known type of object than admitting the possibility of an entirely new sort of celestial entity.

The strongest evidence in support of brown dwarfs was reported in the summer of 1989 by a group led by William J. Forrest of the University of Rochester. In an approach similar to Zuckerman and Becklin's, Forrest's team set out to detect brown dwarfs by their heat; the difference was that they would look for ones thought to be at their hottest. During the first million years of its existence, a body destined to become a brown dwarf should

STARS

By Patrick Moore, O.B.E.



Above: Pluto is so small and so far away that even the giant 200-in (508-cm) Hale telescope shows it only as a faint star. These two photographs show Pluto's motion against the background of the stars over 24 hours.

results in the flattening of the polar regions. But this effect is even more marked than with Jupiter; there is a difference of nearly 13,000 km (8000 mi) between the polar and equatorial diameters.

Beyond the Naked Eye

On the fringes of the solar system beyond Saturn are three more planets so distant as to be beyond the normal range of vision. First is Uranus, discovered by William Herschel in 1781; then Neptune, discovered by J. Galle in 1846; and finally Pluto, discovered by Clyde Tombaugh as recently as 1930.

Uranus is classed as a giant planet, too, with a diameter nearly four times that of Earth. It is much smaller than Jupiter and Saturn, but it is very much like these planets in many ways. It is primarily a gaseous body of low density covered with a thick atmosphere of hydrogen and methane. No ammonia is present, which is to be expected at the very low temperatures existing there (-200°C). Uranus also rotates rapidly on its axis and is markedly flattened at the poles. Its internal structure is believed to be much like that of Jupiter and Saturn.

The planet can be seen with binoculars, but scarcely ever with the naked eye. This is not surprising, since it lies twice as far away from us as Saturn. Even with a powerful telescope Uranus appears as little more than a greenish-yellow disc, with vague markings that could be cloud belts.

The most remarkable feature of Uranus is the enormous tilt of its axis (98°). As a result of this tilt, the planet's axial rotation is effectively retrograde, and so are the motions of its five satellites - Miranda, Ariel, Umbriel, Titania and

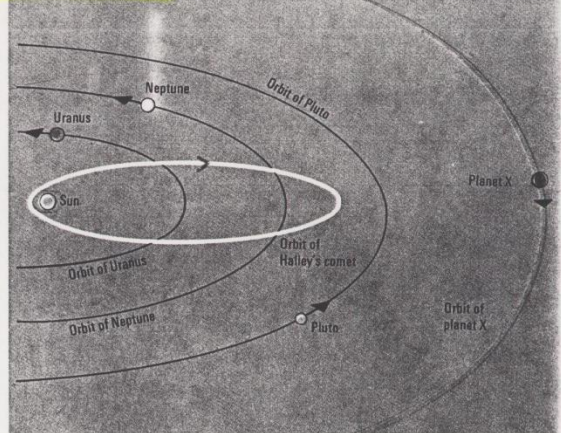
Oberon - none of which exceeds 1000 km (620 mi) in diameter.

Neptune is a near-twin of Uranus, being almost identical in size and in constitution. (Neptune is in fact fractionally bigger, with a diameter 1200 km (745 mi) greater.) Being much farther out than Uranus, Neptune can never be seen with the naked eye, and even a telescope will show no details on its disc. It is several degrees colder than Uranus. The planet has two satellites. Triton is nearly as large as Mercury, and has a retrograde circular orbit relatively close to the planet. Nereid is only about 250 km (150 mi) across, and its orbit is distant and highly eccentric.

The farthest known planet, Pluto, differs in every respect from its planetary neighbours. It is a very small body, only a little bigger than Mercury. It is thought to be made up of rock, overlain with frozen gas. It rotates very slowly - once in every 6 days or so.

On average Pluto lies nearly 600 million km (3700 million mi) from the Sun. But its orbit is unusually eccentric. Periodically, Pluto travels *inside* the orbit of Neptune; it is doing so at present. The possibility of collision between the two planets is, however, almost negligible, since Pluto's orbit is inclined by some 17° - very much more than that of Neptune, or indeed any other planet. Some astronomers believe that Pluto is a former satellite of Neptune.

Below: The orbit of a possible tenth planet, planet X, whose existence was predicted as a result of computer studies by American astronomer Joseph Brady in 1972. Brady maintains that a planet three times more massive than Saturn is causing the irregularities observed in the orbit of Halley's comet. It circles the Sun in a retrograde (clockwise) direction at a distance of some 10,000 million km (6200 million mi) and takes 464 years to complete one orbit. Its orbital plane is inclined 60° to that of the Earth.



9

Last night I went into my observatory, uncapped my telescope, and pointed it in the direction of the planet Pluto. There was the tiny, remote world—looking like a dim star, and yet so profoundly unstarlike. Generally it is regarded as the outermost planet—but this is not always true—and many astronomers feel that Pluto shouldn't be there at all!

Pluto was tracked down in 1930 as the result of calculations by the American astronomer Percival Lowell, best remembered today for his fascinating (and, alas, completely erroneous) ideas about the canals of Mars. Lowell based his calculations on the disturbing effects of a then-unknown source upon the giant worlds Neptune and Uranus, and had, so to speak, carried out a detective's investigation in reverse. He was right; Pluto proved to be just where he had plotted it.

Yet—something was wrong. Pluto was found to be very small, with a diameter less than that of the earth or even of Mars. How could such a midget planet possibly drag Uranus or Neptune out of position by any measurable amount? Yet it was by these very perturbations that Pluto had been discovered. It was all very odd; and to make matters worse, Pluto has an orbit that periodically brings it closer to the sun than Neptune (although there is no chance of collision). From January 1979 to the year 1999, Neptune, not Pluto, will be the outermost planet of our solar system!

What is the nature of the peculiar Pluto discovery? No one yet knows.

In the meantime there has been an exciting development with Pluto. Studies carried out at the Flagstaff, Arizona, station of the U.S. Naval Observatory and at Cerro Tololo Observatory in South America indicate that Pluto may have a satellite, or moon, with a diameter larger than half the diameter of Pluto itself! The moon seems to circle Pluto once each Plutonian day (about 6 1/4 earth days), and is about 20,000 kilometers away. It is still too early to be sure, but the satellite may well be there—in which case, it would make Pluto a double, or binary, planet.

Might there be another planet far beyond either Neptune or Pluto? If so, what are the chances of finding it? It must be

cold, lonely, and remote beyond all understanding; from it, the sun would only be as brilliant as the full moon condensed to the size of a brilliant star. Tracking down such a world would be a Herculean task. But Planet Ten is a good possibility, and its discovery might help explain the history of the outer reaches of the solar system.

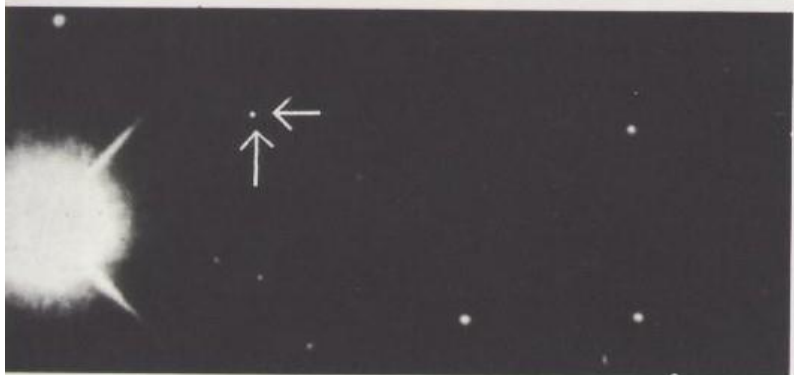
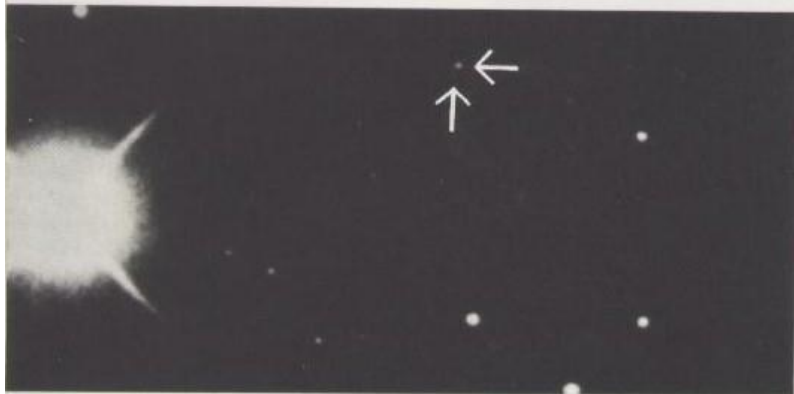
Speaking of satellites, another recent report is of real interest, this time concerning the asteroids or minor planets—dwarf worlds orbiting the sun in the gap in the solar system between the orbits of Mars and Jupiter. One of them, a very faint body 240 kilometers across, is named Herculina. On June 7 Herculina passed in front of a somewhat brighter star and occulted (hid) it for a few seconds. Remarkably, that star winked not once but twice—from this startled observers in California inferred that the asteroid Herculina may not be a solitary wanderer. According to calculations by David W. Dunham of the International Occultations Timing Association, Herculina may have a satellite of its own, some 50 kilometers across and 1000 kilometers away.

Herculina may not be the only asteroid so honored. The idea that minor planets could have satellites was first conjectured as long ago as 1901. Several astronomers in the 1920's and 1930's made observations that seemed to indicate that the large minor planets Eros and Pallas have companions. In recent years those reports have been confirmed by other observers watching those asteroids occult stars.

Asteroids could be troublesome little bodies. When the first *Pioneer* spacecraft went out toward mighty Jupiter, they had to pass right through the asteroid belt, and there was serious fear that they might be destroyed colliding with a chunk of cosmic debris. Luckily that did not happen—there may be fewer very small asteroids than we once thought—but a hit from a sizable piece of rock would destroy any probe in a fraction of a second. We can only hope a means of protection more reliable than luck will be devised before human beings start to invade those perilous regions.

We will, of course, go there someday. ☐

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Discovery of Pluto *left*

The two photographs show the discovery of Pluto in March 1930. The upper photograph was taken on 2 March, and the lower on 5 March; the large object to the left is the very over-exposed image of the 3rd-magnitude star Delta Geminorum. Pluto has moved perceptibly in the interval. Tombaugh was using a blink-microscope, a special device by which two photographic plates can be viewed alternately in rapid succession; any object that has moved in the interval is seen to "jump". It was subsequently found that Humason, in his earlier search, had photographed Pluto twice, but on the first occasion the planet was masked by the image of a star, and on the second occasion Pluto's image fell upon a flaw in the photographic plate!

Data

Distance from Sun
 max. 4,566,000,000 miles
 mean 3,666,000,000 miles
 min. 2,766,000,000 miles
Period of revolution
 247.70 years
Synodic period 366.7 days
Orbital eccentricity 0.246
Orbital inclination 17°10'
Mean orbital velocity
 2.9 miles per second
Axial rotation period at equator 6d. 9h.
Diameter 3700 miles (?)

A Trans-Plutonian Planet?

If Pluto is not the planet which Lowell sought, it is quite likely that a tenth planet exists. Unfortunately it will be very difficult to locate, because its effects upon the orbits of Uranus and Neptune will be very slight, while Pluto has not yet been followed for even half of a complete revolution (its period is almost 248 years, and it was discovered less than 50 years ago). Moreover, the hypothetical planet must be extremely faint. Only the world's largest telescopes could hope to photograph it, and they are fully occupied with stellar work.

OPINION BY
 BRITISH
 ASTRONOMER
 PATRICK MOORE



NEW CONCISE ATLAS OF THE UNIVERSE
 MITCHELL BEAZLEY PUBLISHERS LTD. © 1978

Comets tell of planet that exploded into asteroids

Could the asteroids—the small bodies lying between the orbits of Mars and Jupiter—be the result of a planetary breakup that occurred several million years ago? This is the idea put forward by T. C. Van Flandern of the US Naval Observatory writing in the current issue of *Icarus*, (vol 36, p 51).

The theory that the asteroids are the debris of a shattered planet was suggested as long ago as 1801 by the German astronomer, Heinrich Olbers, after the discovery of the second asteroid, Pallas. Later the French mathematician J. L. Lagrange considered that comets could be the byproduct of a planetary explosion.

Van Flandern has analysed the orbits of very long period comets and presents evidence that all comets originated simultaneously in our Solar System some five million years ago. He suggests that long period comets are fragments from the planet's explosion that marginally failed to escape and are now raining back in on the inner Solar System. When they entered the Solar System for

the first time their orbits still preserved their original character and had not been perturbed by the planets into short period comets or ejected permanently into interstellar space.

Van Flandern cites recent work by Michael Ovenden, professor of astronomy at the University of British Columbia, with computer models of the Solar System. These suggest that the orbits of the inner Solar System became stable while there was a massive planet, some 90 times the mass of the Earth, in an orbit between Mars and Jupiter.

As there is now only about one-thousandth of the Earth's mass in the asteroid belt the breakup must have had great energy and been very violent. Almost all the planet's mass would have been either swept up by the Sun or Jupiter or ejected from the Solar System leaving only two kinds of orbit—the asteroids and long period comets with periods of about five million years having made no more than one revolution about the Sun. What evidence is there for the breakup of such a planet?

Some debris could have found orbits about the planets. Phobos, the asteroid-like satellite of Mars which is in an unstable orbit and heading for destruction in the Martian atmosphere, could be an example of a recently captured satellite. Comets and meteors could constitute debris. So could tektites, small glassy bodies found on Earth with low ages as deduced from cosmic ray exposure which are probably of meteoric origin.

Moreover Van Flandern proposes that the planetary breakup could have had more dramatic effects. The influx of water vapour from the broken planet could have triggered off the series of ice ages that began a few million years ago. Jupiter's great red spot could be where a large mass, possibly the satellite of the broken planet, hit it.

Van Flandern does not explain how such a violent effect could have taken place, but he does suggest that such an event could have temporarily outshone the Sun and it could be that some of the novae seen around other stars may not be stars blowing up, but planets. □

SHOALS OF SPACE

STARS

By Patrick Moore

I began a recent lecture by stating that for the benefit of absolute beginners I would spend a few moments going back to square one—anybody who knew the difference between an asteroid and an adenoid could take a quick nap. Many people in the audience had no idea what an asteroid was, but asteroids are important, if only because they have been regarded as real hazards to spacecraft traveling through the solar system.

At the moment we have had four vehicles (*two Pioneers* and two *Voyagers*) that have threaded their way through the danger zone without meeting disaster. This may indicate that there is less cause for concern than was supposed regarding the density of the asteroid belt. But it would be foolish to be overconfident, for one simply cannot maneuver a spaceship, manned or unmanned, to dodge an asteroid as it happens along.

Asteroids are dwarf planets. Most of them move around the sun between the orbital paths of Mars and Jupiter, thereby dividing the solar system neatly into two

parts. Ceres, the largest asteroid, is no more than 1100 kilometers across, and there are many members of the swarm that are no more than a kilometer or two across. Only one, Vesta, is ever visible to the naked eye, and even Vesta appears only as a dim, starlike point.

Oddly enough, the asteroid belt—or, rather, a planet in the same region—was predicted, prior to the nineteenth century, long before it was actually found. Two German astronomers, Titius and Bode, calculated a mathematical relationship linking the distances of known planets from the sun. Their calculations indicated a gap in the solar system between the orbits of Mars and Jupiter.

Known as Bode's law, it was, in fact, first drawn up by Titius (science is not always logical). Frankly, I have a profound distrust of the law, and regard it as being in the category of those juvenile "take-away-the-number-you-first-thought-of" games. Yet when first proposed it was taken quite seriously.

Some asteroids may wander away from

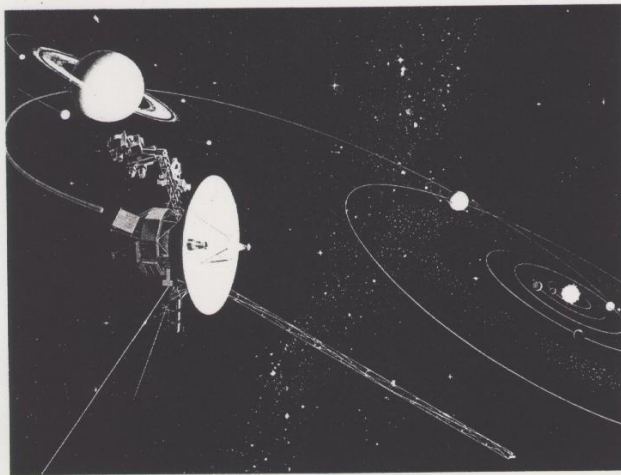
their main orbital zone and approach the earth. In 1937 Hermes, a mere kilometer in diameter, brushed past us as close as 775,000 kilometers, less than twice the distance to the moon. One British newspaper printed the memorable headline "World Disaster Missed by Four Hours: Tiny Planet Whizzes Past." There is always a chance of a direct hit; and the damage, while it may not result in worldwide devastation, would be quite serious.

Other peculiar asteroids are known. One, Icarus, goes within 25 million kilometers of the sun, so that at times it must be red-hot. Another, Eros, is shaped like a cosmic sausage, 29 kilometers long and about 14 kilometers wide. We also have a true oddity, Chiron, which wanders around the solar system between the paths of Saturn and Uranus. Whether Chiron is a real asteroid we still don't know—it is approximately 640 kilometers across, which by asteroidal standards is large. **What made the asteroid belt? One theory is that a planet in that part of the sun's family exploded for some unknown reason. It may be that there were two old planets that met head-on, with cataclysmic results.** Or, more plausibly, the asteroids were produced from material that never formed into a larger body.

They must be barren worlds—bleak, airless, waterless, and lifeless. Go to one, and you will weigh little more than a postage stamp. You would be able to leap clear from a small asteroid by sheer muscle power, thereby becoming a tiny independent planet in your own right.

There have been suggestions of mining valuable minerals from asteroids (if such material exists). Perhaps their best use might be as unmanned observatories—particularly Icarus, from which the sun would be magnificent indeed. But well-placed probes *could* tell us the mineral value of asteroids.

There was a film in which the hero went up in a spaceship, equipped with a large net, and began asteroid fishing. Even though, so far as I know, he had little luck, these dwarf planets are full of interest. Surely we must hold them in less contempt now that we have successfully navigated these shoals in space. ☐



Two Pioneer unmanned vehicles have successfully passed through the asteroid belt.

World VANCOUVER PROVINCE es Russians at UN

But Soviet Ambassador Oleg Troyanovsky said: "I am not enthusiastic. This is definitely not a contribution to disarmament and peace."

Reagan portrayed the United States as the real champion of arms control and accused the Soviets of a "record of tyranny" that included violating existing arms control pacts and the 1925 Geneva protocol banning the use of chemical weapons.

Reagan assailed Moscow for stifling a budding peace movement at home, dominating Eastern Europe, building the Berlin Wall and

supervising "the ruthless repression of the proud people of Poland."

"Soviet-sponsored guerrillas and terrorists are at work in Central and South America, in Africa, the Middle East, in the Caribbean and in Europe, violating human rights and undermining the world with violence," Reagan said. "Communist atrocities in Southeast Asia, Afghanistan and elsewhere continue to shock the free world as refugees escape to tell of their horror."

"In Moscow (peace) banners are scuttled, buttons are snatched and demonstrators are arrested when even a few people dare to speak out about their fears."

Mystery of stars nearing solution

MOUNTAIN VIEW, Calif. (UPI)—A pair of American spacecraft may soon discover what **mystery object**—a tenth planet—a **black hole** or a **visiting (dark star)**—is throwing Uranus and Neptune 1965 km off course each year, NASA scientists said Thursday.

From data going back to Galileo, Neptune and Uranus are known to be regularly pulled from their predicted orbits by gravitational force—but the cause of their deviation from their predicted orbits has never been determined.

A 1978 report by the U.S. Navy's Observatory discarded a possible explanation, long favored, that the effect was produced by the planet Pluto. The theory was abandoned after the discovery of a satellite of Pluto, called Charon, leading to a recalculation of Pluto's mass.

Scientists found the Pluto-Charon mass was only about one-fifth the mass of the Earth's Moon, far too little to account for the tiny but regular shifts in the orbits of Neptune and Uranus.

They said a **large, dark-star-type object** perhaps as big as the Sun and perhaps 50 billion miles beyond the outermost planet could produce the orbital shifts in the two planets. A vastly larger black hole twice as far away is also consistent with the findings.

Or, according to the scientists, the pull of an **undiscovered planet-sized object** perhaps five billion miles beyond the Pluto-Neptune orbits would also explain the phenomenon.

The space agency said its scientists last summer began approaching the problem with data from Pioneer 10 and 11, the most distant man-made objects in the solar system. Data analysis will begin in October and an answer might come in three years.

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'MYSTERIOUS UNIVERSE'
A HANDBOOK OF ASTRONOMICAL
ANOMALIES

NEW PLANET MAY BE ADDED TO THE SUN'S FAMILY OF NINE
Anonymous; *Science Newsletter*, 41:361, 1942.

A new planet about the size of Pluto but a little less distant may be added to the sun's family, which already contains nine members.

No such tenth member has yet been found, but the attraction of such a body would account for the three days' delay in the return of Halley's comet in 1910, according to the calculations of Dr. R. S. Richardson of Mt. Wilson Observatory reported in the *Publications of the Astronomical Society of the Pacific* (February). And he has told astronomers just where to look for the new body. It should now be found, he says, at about right ascension 16 hours, declination minus 20 degrees. These figures enable astronomers to point their instruments directly at the suspected spot.

At first, Dr. Richardson thought Pluto might be the culprit that held back Halley's comet. But it turned out that Pluto was miles away at the time---in fact, more than three billion miles away. This was the very closest the planet ever got to the comet, and it happened in October, 1901. Also Pluto is so tiny, only about as big as the earth! Finally, Dr. Richardson's very careful calculations showed that if Pluto had any effect at all, it was in the wrong direction; it would have hastened rather than delayed the comet.

.....

What is needed to explain the comet's dilatory behavior, Dr. Richardson found, is a planet whose orbit just grazes the furthestmost tip of Halley's orbit, grazes it by about 9,000,000 miles. The planet would be about the size of Pluto or the earth. A larger planet at a greater distance would also do the trick, but the planet must be small because otherwise it would have been discovered.

If this planet is found, it will be the third to have been predicted mathematically and afterwards discovered. The other two are Neptune, discovered in 1846 from the calculations of Leverrier and Adams, and Pluto, discovered in 1930 from the calculations of Lowell and Pickering.

A FORMER MAJOR PLANET OF THE SOLAR SYSTEM
Van Flandern, T. C.; *EOS*, 57:280, 1976.

Abstract. Recent dynamical calculations by M. W. Ovenden have demonstrated the former existence of a 90-Earth-mass planet in the asteroid belt until 16×10^6 years ago. These calculations have now been strikingly confirmed by the discovery that very-long-period comets apparently originated in the explosion of such a planet at that epoch. The evidence from comets is present in the distributions of each orbital element; but the most compelling evidence comes from a backwards integration of 60 well-observed very-long-period comets to their previous perihelion passage, which shows that most of these intersect at

BY: WILLIAM R. CORLISS ©1979
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nearly the same point on the heliocentric celestial sphere. Taken in conjunction with the already existing evidence, these new results leave little room to doubt that a Saturn-sized planet did exist between Mars and Jupiter 16 million years ago, and then violently exploded.

COMETS AND CLIMATIC CHANGES

Anonymous; *Nature*, 176:1152-1153, 1955.

In a paper entitled "Evidences Cometaires des Variations des Climats" (*Bull. Astro. Inst. Czechoslovakia*, 6, No. 1; 1955), F. Link and Z. Linkova deal with statistical research relating to the discovery of comets, correlated with solar activity. They have found that the annual number of comets discovered varies in the course of the solar cycle of eleven years. This variation is inversely proportional to rainfall, with two maxima during the eleven years, according to Helman's investigations, and more recently it has been found that the number of comets discovered during a cycle is greater in the even than in the odd cycles. The numbers of comets discovered between 1755 and 1953 are arranged in cycles 1-18, and then the mean number of discoveries per year in the successive cycles is given separately for even and odd cycles. The influence of the meteorological conditions on the observations of comets is shown by means of a graph. Solar activity being greater during the odd cycles, the circulation in the terrestrial atmosphere is increased, and in consequence observations become more difficult; as a result of this, there is a decrease in the number of comets observed.

This close connexion between the number of comets discovered and the meteorological conditions (the latter depending on solar activity) led the authors to carry out investigations on climatic variations since 1611, and the principle underlying this research is based on the assumption that the number of comets discovered is a function of three factors: the cosmic factor, that is, the actual number of comets that approached the Earth; the climatic factor, or the atmospheric conditions in civilized countries, which only need be included, as observations of comets in uncivilized countries would be useless for statistical purposes; the social factor or human activity (in particular, astronomical activity) in civilized countries. While the first factor can be regarded as constant, the second would increase in a more-or-less continuous manner in time, and the third would be revealed in the slope of the curve $N = f(A)$, N being the number of comets discovered from zero year up to the year A . Both these quantities have been taken from a catalogue by Baldet ("Ann. Bur. Long", Supp. 1950), and a searching analysis of the results leads to certain conclusions on the meteorological conditions between the years 600 B.C. - A.D. 1740. A comparison is made between these and the data given by C. E. P. Brooks in "Climate through the Ages", covering about a thousand years up to comparatively recent times, and there is a close accordance between them. The Czechoslovak workers hope to carry out further investigations on the subject.

The most exciting possibility is that another undiscovered planet exists somewhere beyond the orbit of Pluto. Fantastic as the idea sounds it seems the best explanation of the discrepancies in the orbits of Uranus and Neptune. Some astronomers have even tried to work out the characteristics of the mysterious planet. Latest calculations show it could be orbiting on average over 5700 million miles from the Sun. At this distance it would need to have a diameter of about 10,000 miles and a mass six times as great as the Earth.

In July 1978 another remarkable discovery was made from an observatory near Lowell's home in Flagstaff. An American naval astronomer, James Christy, was trying to refine details of Pluto's orbit when he noticed an apparent elongation in the image of the planet on a photographic plate. Subsequent studies have tended to confirm Christy's conclusion that the elongation is due to the existence of a moon orbiting close to Pluto. Christy has called it Charon for the mythological boatman who ferried souls into the underworld.

Charon is an extremely unusual satellite. It appears to have a diameter about 40 percent that of Pluto, making it larger

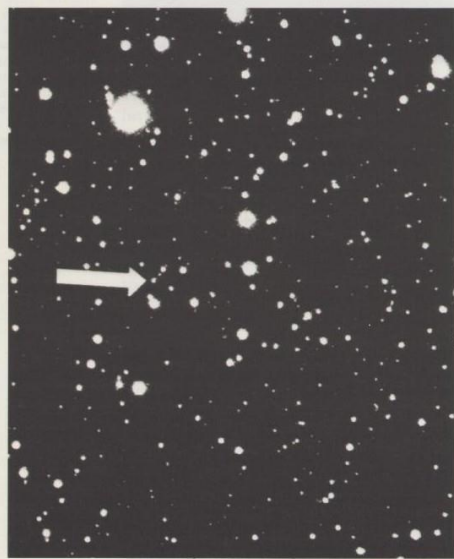
Below: two photographs taken by American astronomer Clyde Tombaugh at Lowell Observatory, Arizona, in 1930, show the planet Pluto (arrowed) for the first time. It had been predicted as early as 1905, when the American astronomer Percival Lowell showed that there had to be a ninth planet to account for small irregularities in the orbit of the recently discovered Neptune. Pluto had evaded earlier detection because it was unexpectedly faint. The planet remains largely a mystery. A moon was discovered around the remote planet in 1978, which led to a reassessment of its size — it is now thought to be both smaller and lighter than at first predicted.

in proportion to its mother planet than any other satellite in the solar system. Even more remarkable is the fact that Charon orbits Pluto in 6.4 days, exactly the same time as it takes Pluto to complete a rotation on its axis. This means that Charon must hang stationary over one point on Pluto's surface, a phenomenon unique in the solar system.

Some astronomers even question whether Pluto is a true planet at all. Its similarity to some of the larger moons of the giant planets suggest it may actually have once been a moon of Neptune torn loose by some ancient cataclysm, perhaps even by the intrusion of the mysterious tenth planet.

At the moment scientists can only speculate about conditions on the surface of Pluto. Temperatures must be close to absolute zero and even if the planet had ever possessed an atmosphere, its gases would now lie frozen or liquefied on the surface. The Sun would appear as a bright star but its light would hardly be strong enough to illuminate Pluto's bleak landscape.

Pluto is a lonely outpost world. Beyond its remote orbit lies only the unresolved mystery of the tenth planet and then the vast gulf of interstellar space.

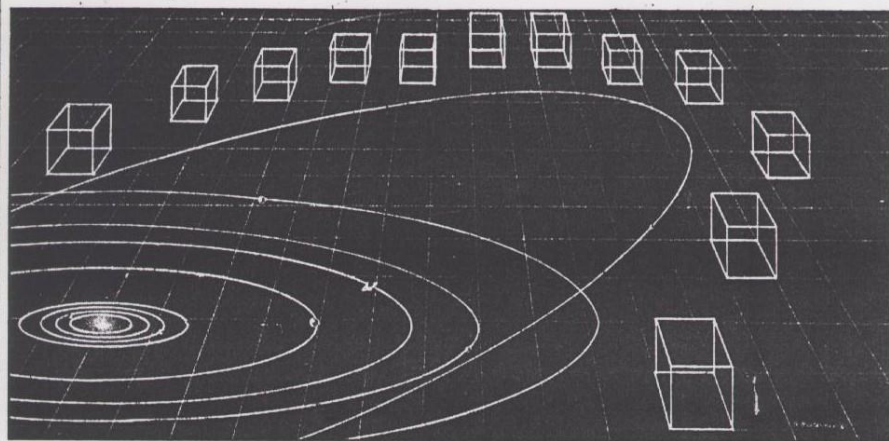


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SEARCH FOR THE TENTH PLANET

Astronomers are readying telescopes to probe the outer reaches of our solar system for an elusive planet much larger than Earth. Its existence would explain a 160-year-old mystery.



Scientists are utilizing an IBM 4341 computer to combine educated guesswork with hard astronomical facts and come up with a list of likely regions past Pluto where a yet-undiscovered planet could be slowly circling the Sun. The pull exerted by its gravity would account for a wobble in Uranus' orbit that was first detected in 1821 by a French astronomer, Alexis Bouvard.

Beyond Pluto, in the cold, dark regions of space, may lie an undiscovered tenth planet two to five times the size of Earth. Astronomers at the U.S. Naval Observatory (USNO) are using a powerful computer to identify the best target zones, and a telescopic search will follow soon after.

Previous planetary observations show why astronomers believe a tenth planet may exist. In 1821, 40 years after the discovery of the seventh planet, Uranus, the French astronomer Alexis Bouvard noticed that its observed position did not agree with its calculated orbit. The planet was being perturbed, or pulled slightly off course, by the gravitational attraction of an outer planet. Working independently, an Englishman, John Couch Adams, and U.J.J. Leverrier of France used the discrepancy to calculate the theoretical position of an eighth planet, Neptune, which was finally spotted in 1846 by John Galle of the Berlin Observatory. But the mass of the new planet did not fully account for the distortion of Uranus' orbit, and so a search was begun for a ninth planet. Pluto was discovered by Clyde Tombaugh, working with photographic methods, on February 18, 1930.

However, tiny Pluto is 100 to 1,000 times too small to fully account for Uranus' wobble, according to Thomas Van Flandern of the USNO. A brief flurry of excitement followed Charles Kowal's 1977 discovery of the planetoid Chiron, orbiting between Saturn and Uranus, until it was determined that it was too minute to be

planet 10. Van Flandern notes that the search for the planet "Vulcan," once proposed to account for Mercury's strange orbit, ended when Einsteinian physics revealed that the distortion of space caused by the Sun's huge mass created the irregularity. Another unexpected change in physical law is possible, he says, but "our best bet is for a tenth planet out there."

How to find it? First make some educated guesses about position and mass. Van Flandern thinks the tenth planet may have between two and five Earth masses and lie 50 to 100 astronomical units from the Sun. (An astronomical unit is the mean distance between Earth and the Sun.) His team also presumes that, like Pluto's, the plane of the undiscovered body's orbit is tilted with respect to that of most other planets, and that its path around the Sun is highly elliptical. By having an IBM 4341 computer match these assumptions against a huge quantity of astronomical data, the scientists obtained a list of places to start looking.

Although the computer has made their task a little easier, the astronomers don't count on finding a planet right away—the odds against it are literally astronomical. What will they call it if they do? Tradition says the name should come from Roman mythology, but as one researcher struggled over his calculations, he was heard to mutter something about "finding Humphrey." For the moment, the significance of this name remains as unclear as the location of the elusive planet.

Something lurking behind the planets

THE HUNT for a tenth planet is officially on, say American space scientists. A special conference held at NASA's Ames Research Center last week decided that the weight of evidence assembled at the US Naval Observatory, the Massachusetts Institute of Technology and the Jet Propulsion Laboratory in California is too strong to deny that something is lurking beyond the outer reaches of the known Solar System.

The research centres have pooled tens of thousands of observations of the giant, outer planets Uranus and Neptune. Anomalies in the planets' behaviour, say researchers, can be caused only by a large mass outside the orbit of Pluto. One of the earliest

sources of this data is the work of Clyde Tombaugh, who discovered Pluto in 1930. Tombaugh attributed oddities in the orbit of Uranus to his new discovery. But the combined mass of Pluto and its satellite Charon is so small—only a fifth that of our own Moon—that this could not possibly be the explanation of the giant planet's strange behaviour.

The data presented at NASA's conference point to two explanations for the deep-space phenomenon. There may be a planet about the same size of Uranus



Looking for the tenth planet?

some 5000 million miles beyond the orbit of Pluto. Or it could be something much bigger and further away. The problem for observers on Earth, says Archie Roy of Glasgow University, is that "The Sun could keep any number of planets out to a quarter of the distance to the nearest star, with no trouble."

NASA has its money on a more spectacular interpretation. According to John Anderson, the Jet Propulsion Laboratory's chief investigator, a dark star, companion to the Sun, might be the most

likely explanation. The data suggest either a burnt-out white dwarf or a neutron star, perhaps 50 000 million miles from the Sun (12 times more distant than Pluto), or a black hole, 10 times the mass of the Sun at twice the distance. Support for these ideas is based on the Sun's lonely existence. Most stars are paired.

Observations on the Earth could confirm the presence of a tenth planet, or a second star, within a century. But NASA is looking for a quicker answer in the flights of Pioneer 10 and 11, the space probes now rapidly approaching the orbit of Pluto but travelling in opposite directions. NASA scientists can measure the speeds and positions of the craft so accurately

that any unexpected variation in their paths would be an obvious sign of some huge, extra source of gravity. A dark star would affect the motion of both probes. If the extra member of the Solar System is somewhat smaller, its effects would register on only one.

Whatever the probes find, NASA is confident that there is something out there. If and when observers do find an extra planet, the benefits to the organisation will be in greater prestige—and perhaps more money—as much as in the romance of discovery. □

Does the Sun Have A Dark Companion?

The laws of celestial mechanics are so well established that when heavenly bodies seem to violate them, astronomers tend to question what they see, rather than what they believe. When scientists noticed that Uranus wasn't following its predicted orbit for example, they didn't question their theories. Instead they blamed the anomalies on an as yet unseen planet and, sure enough, Neptune was discovered in 1846. Now astronomers are using the same strategy to explain quirks in the orbits of Uranus and Neptune. According to John Anderson of the Jet Propulsion Laboratory in Pasadena, Calif., this odd behavior suggests that the sun has an unseen companion, a dark star gravitation-

ally bound to it but billions of miles away.

A "dark companion" could produce the unseen force that seems to tug at Uranus and Neptune, speeding them up at one point in their orbits and holding them back as they pass. At first scientists blamed the orbital fits and starts on the gravity of Pluto. But four years ago they discovered that Pluto was far less massive than had been thought, and astronomers began to look elsewhere for the source of the mysterious force.

Dwarf: Almost any dark object would fit the bill, but Anderson thinks the best bet is a dark star orbiting at least 50 billion miles beyond Pluto, which is 3.6 billion miles from the sun. It is most likely either a brown dwarf—a lightweight star that never attained the critical mass needed to ignite—or else a neutron star, the remnants of a normal sun that burned out and collapsed.

Other scientists suggest that the most

likely cause of the orbital snags is a tenth planet 4 to 7 billion miles beyond Neptune. A companion star would tug the outer planets, not just Uranus and Neptune, says Thomas Van Flandern of the U.S. Naval Observatory. Anderson admits a tenth planet is possible, but argues that it would have to be so big—at least the size of Uranus—that it should have been observed by now.

To resolve the question NASA is staying tuned to Pioneers 10 and 11, the planetary probes that are floating through the dim reaches of the solar system on opposite sides of the sun. If one undergoes a sudden tug, that would suggest the existence of a nearby tenth planet that would affect only the Pioneer closest to it. If both change course, the case for a distant and powerful dark star would get a boost. But unless NASA gets \$3 million to monitor the probes beyond 1982, the Pioneers' messages will fall on deaf ears.

THE LOCATION OF PLANET X

R. S. HARRINGTON

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Received 17 May 1988, revised 12 July 1988

ABSTRACT

Planet X, if it exists at all, is most likely to be found, at present, in the region of Scorpius, with a considerably lesser likelihood that it is in Taurus.

In 1930, Tombaugh found the planet Pluto. This was the result of a systematic search initiated at Lowell Observatory as the result of predictions made by Lowell as to the position and nature of a supposed additional planet in our solar system. At the time, Pluto was hailed as the object of that prediction, even though there were anomalies in its appearance and orbit evident right from the time of its discovery. Since then, these problems have only become more serious, and the discovery of its satellite in 1978 revealed a mass of Pluto that could not have caused any of the perturbations in the orbits of Uranus and Neptune used to predict the existence of a ninth planet. For a complete review of the discovery of Pluto and the developments leading up to the suspicion of the existence of a tenth planet, see Seidelmann and Harrington (1988).

The motions of Uranus and Neptune cannot be adequately represented within the present gravitational model of the solar system. Pluto cannot have any detectable effect on these two planets. There is therefore a good possibility that there is at least one undetected planet in our solar system, and it is now possible to set some constraints on where that planet might be.

The observations used in this study were taken from compilations of all positional determinations available through 1982 for each planet of interest. These observations are quite varied in nature and source and include both visual and photographic determinations. The Uranus observations go back to 1833 and the Neptune ones to 1846. These compilations were supplied by the Nautical Almanac Office of the U. S. Naval Observatory. They consist of observed positions of Uranus and Neptune, along with residuals in right ascension and declination from positions computed from DE200 (Standish 1982a,b). The residuals were first converted to residuals in ecliptic longitude (great circle) and latitude. As a statistical approximation, this is not correct, since these data are not statistically independent. However, for the present analysis this makes no difference, and it greatly facilitates the subsequent comparison with numerical simulations.

These residuals were then combined into seasonal normal points, producing average geocentric residuals spaced slightly more than a year apart. These residuals were then assumed to be adequate representations of the equivalent heliocentric average residuals for the observed oppositions. There are usually enough observations per opposition, with enough balance pre- and post-opposition, that the small systematic errors within each observation should tend to cancel out in the mean. The exception would be that, in the mean, heliocentric residuals should be, at most, a few percent smaller in magnitude, an effect that is well below the noise level within each normal point. In any case, these short-period differences do not affect the long-period effects being

sought. Finally, a weight was assigned to each normal point. Weights based upon the rms scatter within each normal would give the bulk of the weight to the observations after about 1920, and therefore on modern transit-circle observations. However, it is important to give enough weight to early observations to give them some significance in a solution for long-period effects. Therefore, the weights were based merely on the square root of the number of observations per normal. A few tests indicated that this consideration is not significant for the final results.

The item of interest for the present analysis is the perturbation in the orbit of a known planet, produced by the presence of an unknown Planet X. (X can be thought of as either representing the unknown or the number 10.) Hence, the equations of motion are cast in the form of the motions of the residuals in rectangular coordinates. For numerical work, this is known as Encke's method, and the description followed here comes from Brooker and Clemence (1961). The method relies on the fact that it is being applied only to the orbits of Uranus and Neptune. These planets are sufficiently distant, move sufficiently slowly, and are perturbed sufficiently little that all vectors representing planetary positions, whether known or unknown but assumed, as they appear in the derivatives of the perturbations, can be represented by approximate vectors. For assumed Planet X orbits, two-body motion is assumed. For Uranus and Neptune, the low-precision formulas as given by Van Flinders and Palkkinn (1979) are employed.

Additional assumptions are that the perturbations are sufficiently small that expansions in them are only required through first order and that the mass of the perturbed planet need not be included in the solar gravitational constant representing the principal term in the acceleration of the perturbation (both of these have been numerically verified). The result of this development is a set of relatively simple equations of motion that can be integrated very quickly for a given orbit of Planet X. A reintegration of the entire outer solar system is not needed for each test case and, indeed, only the positions of the perturbing and the perturbed planets (the perturber and the perturbee) are required.

To be specific, let \mathbf{k} be the vector of perturbations of an observed planet, caused by Planet X, from the vector \mathbf{r} of the predicted position of the observed planet, based on the known gravitational model of the solar system (i.e., the actual vector of observations is $\mathbf{r} + \mathbf{k}$). The vector \mathbf{r} is approximated as described above. Let \mathbf{r}_X be the position vector of Planet X. Let μ be the gravitational constant of the Sun and μ_X be that of Planet X. The equation of motion for the perturbation vector can therefore be written as follows:

$$\ddot{\mathbf{k}} = -\frac{\mu}{r^3} \left(3\frac{\mathbf{r}\mathbf{r}}{r^2} \mathbf{r} - \mathbf{k} \right) + \mu_X \left(\frac{\mathbf{r}_X - \mathbf{r}}{|\mathbf{r}_X - \mathbf{r}|^3} - \frac{\mathbf{r}_X}{r_X^3} \right)$$

THE LOCATION OF PLANET X

R S Harrington

American Astronomical Society

Provided by the NASA
Astrophysics Data System

Comme vous le constatez , la documentation est abondante.

Puisque les planètes ont des déviations de leurs orbites ,
il est obligatoire qu'un ou plusieurs gros objets existent ,
même si on ne les voit pas.

Voici pourquoi on ne peut pas les voir :

**de 83 % à 90 % de la densité totale de l'Univers est constitué de
matière noire.**



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Matière noire

Ne doit pas être confondu avec énergie sombre ni Trou noir.

En astrophysique, la **matière noire** (ou **matière sombre**), traduction de l'anglais *dark matter*, désigne une catégorie de matière hypothétique jusqu'à présent non détectée, invoquée pour rendre compte d'observations, notamment les estimations de masse des galaxies, des amas de galaxies et les propriétés des fluctuations du fond cosmologique.

Différentes hypothèses sont émises et explorées sur la composition de cette hypothétique matière noire : gaz moléculaire, étoiles mortes, naines brunes en grand nombre, trous noirs, etc. Cependant, les estimations de la densité de l'univers et l'estimation de sa densité sous forme d'atomes, la matière baryonique donc, impliquent plutôt une nature non-baryonique, et donc encore inconnue, encore que l'on suppose fortement des particules, peut-être des super-partenaires tels que le neutralino (voir la page sur la supersymétrie). Ces particules exotiques sont regroupées sous le nom générique de WIMP, acronyme de l'anglais *Weakly interacting massive particles* (particules massives à interaction faible), traduction de « mauviettes », d'où l'appellation parfois rencontrée en français¹.

La matière noire aurait pourtant une abondance au moins cinq fois plus importante que la matière baryonique, pour constituer de 83 %² à 90 %³ de la densité totale de l'Univers observable⁴, selon les modèles de formation et d'évolution des galaxies, ainsi que les modèles cosmologiques.

Sommaire [masquer]

- Détection indirecte de la matière noire
 - Premiers indices
 - Les courbes de rotation plate des galaxies spirales
 - Observations récentes
- Répartition de la matière noire dans l'Univers
 - Au sein des galaxies
 - Entre les galaxies, à l'échelle des amas
- Formation des grandes structures de l'Univers
- Nature de cette matière sombre

La matière noire ... constitue de 83 à 90 % de l'univers observable



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Tyche (hypothetical planet)

From Wikipedia, the free encyclopedia

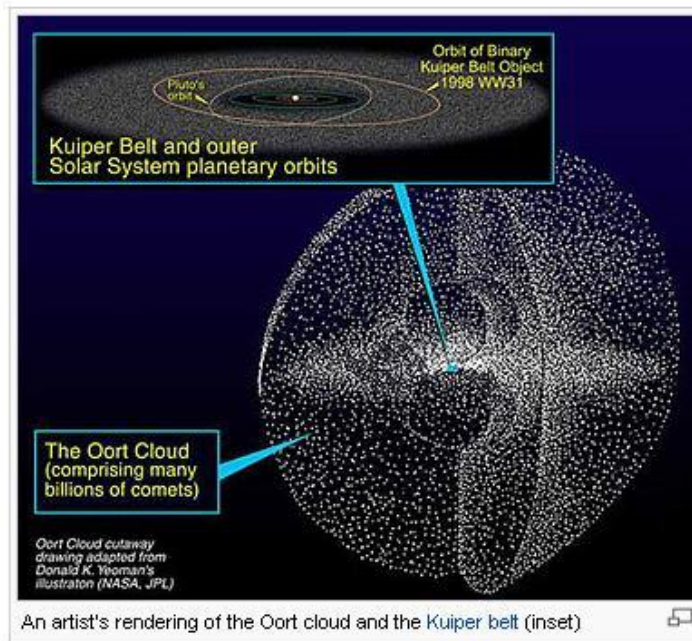
Not to be confused with the hypothetical star Nemesis.

For the asteroid, see 258 Tyche.

Tyche (/ˈtaɪki/) is the nickname given to a hypothetical gas giant planet located in the Solar System's Oort cloud, first proposed in 1999 by astronomer **John Matese** of the University of Louisiana at Lafayette.^{[1][2]} Matese and his colleague **Daniel Whitmire** argue that evidence of Tyche's existence can be seen in a supposed bias in the points of origin for long-period comets. They noted that Tyche, if it exists, should be detectable in the archive of data that was collected by NASA's Wide-field Infrared Survey Explorer (WISE) telescope.^{[3][4]} However, several astronomers have voiced skepticism of this object's existence.^{[2][5]} Analysis over the next couple of years will be needed to determine if WISE has actually detected such a world or not.^[6]

Contents [hide]

- History
- Orbit
- Mass
- Origin of name
- Ongoing research
- See also
- Notes
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Explication de la page de précédente de Wikipedia au sujet de Tyche :

Tyche (/ˈtaɪki/) is the nickname given to a hypothetical gas giant planet located in the Solar System's Oort cloud, first proposed in 1999 by astronomer John Matese of the University of Louisiana at Lafayette.^{[1][2]} Matese and his colleague Daniel Whitmire argue that evidence of Tyche's existence can be seen in a supposed bias in the points of origin for long-period comets. They noted that Tyche, if it exists, should be detectable in the archive of data that was collected by NASA's Wide-field Infrared Survey Explorer (WISE) telescope.^{[3][4]} However, several astronomers have voiced skepticism of this object's existence.^{[2][5]} Analysis over the next couple of years will be needed to determine if WISE has actually detected such a world or not.^[6]

Tyché est le surnom donné à une planète géante gazeuse **hypothétique** situé dans le nuage Oort du système solaire, d'abord proposée en 1999 par l'astronome John Matese, de l'Université de Louisiane à Lafayette. Matese et son collègue Daniel Whitmire soutiennent que la preuve de l'existence

de Tyche peut être vu dans un parti pris supposé dans les points d'origine des comètes à longue période. Ils ont noté que Tyché, **si elle existe**, doit être détectable dans les archives de données qui ont été recueillies par la NASA à grand champ Survey Explorer infrarouge (WISE) télescope.

Cependant, plusieurs astronomes ont exprimé leur scepticisme sur l'existence de cet objet. L'analyse au cours des deux prochaines années seront nécessaires pour déterminer si WISE a effectivement détecté un tel monde ou non.

Voilà en ce qui concerne la planète qu'on appelle souvent par les noms de :

Nibiru - Xena - Hercolubus - Planète X - Katchina - Nemesis.

Tous ces noms désignent la même planète , celle découverte par les anciens sumériens , selon le résultat des travaux de Zecharia Sitchin qui a traduit les textes des sumériens.

La documentation au sujet de Zecharia Sitchin et des sumériens est très abondante sur internet, il est inutile que j'en ajoute.

Dans les prochaines pages , je vais cependant ajouter une information sensationnelle à ce sujet.



Zecharia Sitchin

Voici comment l'homme a été créé ,
selon les 2 théories les plus connues.

1 = Le créationnisme

L'homme a été créé par un Dieu unique , invisible et tout-puissant.

2 = L'évolutionnisme

L'homme est le résultat d'une longue évolution animale.

Maintenant , suite au résultat des travaux de Zecharia Sitchin,
il nous faut ajouter une troisième option :

3 = La manipulation génétique extra-terrestre

Explication sur la page suivante ...

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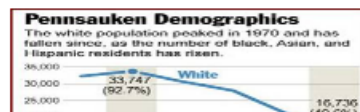
jeudi 29 mars 2012

Nos gènes ne seraient peut-être pas terrien

Découverte de gènes extraterrestres dans l'ADN humain

Dans la revue scientifique *Nature* (409, 860-921, 15/2/2001), un article faisant le point sur l'avancement du **Projet Génome Humain** montre (dans son tableau 24) que **223 gènes humains n'ont aucun prédécesseur évolutif** et ont été **apportés** dans notre chromosome 21 par "*transfert horizontal probable*", c'est-à-dire hors évolution.

Un groupe de chercheurs travaillant au « *Projet du Génome Humain* » (*Human Genome Project*) indique avoir fait une étonnante découverte scientifique. Ils pensent que les séquences dites « *non codantes* » qui composent 97 % de l'ADN humain ne sont rien d'autre que le code génétique de **formes vivantes extraterrestres**. Les séquences non codantes sont communes à toute la matière organique sur terre, des moules aux humains. Dans l'ADN humain, « *elles constituent la plus grande partie du génome total* » déclare le *professeur Sam Chang*, directeur du groupe.



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Ce court texte est un copier-coller de la page précédente.

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Donc,
223 gènes humains n'ont absolument rien à voir avec
le processus évolutif.

Leur origine serait purement extra-terrestre.

C'est en plein le résultat des travaux de traduction
de Zecharia Sitchin à partir des écrits des sumériens qui datent de
plus de 6,000 ans.

Fantastique - mais vrai.

Il existe une confusion au sujet de Nibiru et de Nemesis :

Ce sont 2 objets très différents.

Nibiru revient à l'intérieur de notre système solaire tous les 3,600 ans.

Quand à Nemesis,
il revient tous les 26 millions d'années dans notre voisinage.

Mais
il n'y a aucune raison de s'en inquiéter,
Nemesis ne reviendra que dans 10 millions d'années.

Voir la page suivante pour plus de détails



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Némésis (étoile)

Pour les articles homonymes, voir *Némésis (homonymie)*.

Némésis est le nom donné à un hypothétique compagnon du **Soleil** formant avec celui-ci un **système binaire** à très longue période.

Ce compagnon serait une étoile très peu lumineuse, voire une **naine brune** non détectée à ce jour.

Son orbite serait très excentrique, amenant celui-ci à s'approcher assez près du Soleil à chaque révolution (d'une durée d'environ 26 millions d'années). La proximité du compagnon causerait alors des perturbations dans le **Nuage d'Oort**, amenant un certain nombre de **comètes** s'y trouvant à plonger vers le **Système solaire** interne. Cet afflux de comètes dans la région où sont situées les **planètes** donnerait lieu à des risques accrus de collision entre ces comètes et la **Terre**, et pourrait être responsable d'une grande partie des **grandes extinctions des espèces vivantes**.

Le nom de Némésis est tiré de la **mythologie grecque**, où il représente la **déesse de la vengeance**.

Cet astre hypothétique ne doit pas être confondu avec l'**astéroïde (128) Némésis**.

Sommaire [masquer]

- L'hypothèse Némésis
- Caractéristiques attendues de Némésis
- Problèmes de la théorie
- Influences astronomiques sur le Nuage d'Oort
- Analogue(s) extrasolaire(s)
- Notes et références
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 - Articles connexes
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L'hypothèse Némésis [modifier]

L'hypothèse Némésis est l'œuvre de **Richard A. Muller**, travaillant à l'**université de Californie à Berkeley**. Elle a été proposée en 1984¹.

L'idée de R. A. Muller résulte de l'annonce de la découverte d'une périodicité (aujourd'hui très controversée, voir **extinction massive**) dans les dates des **grandes extinctions** des espèces vivantes sur Terre², ainsi que de la proposition faite par le **Prix Nobel de physique Luis Alvarez** en 1980 que l'extinction des **dinosaures** (dite **extinction du Crétacé**) ait eu pour origine un impact cométaire³.

Muller a ainsi proposé qu'une perturbation périodique du Nuage d'Oort, lieu où résident la majeure partie des comètes du **Système Solaire** soit à l'origine des **grandes extinctions**. La perturbation serait causée par un compagnon du Soleil dont l'orbite se rapprocherait périodiquement du Soleil.

Pour terminer, voici une image récente de Nibiru avec 2 autres objets



Cette image date de décembre 2012

Document produit par :
Ben Garneau



Pour en savoir plus sur Nibiru,
les catastrophes naturelles et le déplacement des pôles
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Nibiru , les catastrophes naturelles et le déplacement des pôles

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Avant tout,

Je tiens à dire que ce la fin du monde n'aura pas lieu le 21 décembre 2012.

Ni en 2013 , ni en 2014 ... ni en 2500.

Notre terre a subi maintes fois des changements brusques, et encore cette fois-ci,
La vie va s'adapter aux changements terrestres qui sont déjà commencés.