



The Solar System Police

Exploring planetary demotions . . . and promotions

They looked for five years toward the far edge of the solar system and found nothing. But in 1992 the tide at last turned for them. Using a new digital camera mounted on the University of Hawaii's 2.2-meter telescope atop Mauna Kea, American astronomers David C. Jewitt and Jane X. Luu swiftly spotted their long-awaited quarry: a fuzzy spot of 23rd magnitude, 4 billion times fainter than the star Sirius. They had found the holy grail for planetary astronomers: an object orbiting the Sun beyond Neptune and Pluto. It was roughly 125 to 150 miles wide.

Over the ensuing years, they and others found many more very much like it. These newly discovered bodies were proof that the "Kuiper belt," a thick ring of icy planetesimals beyond the solar system's outer planets, indeed existed, as proposed in the mid-twentieth century by, among others, the Dutch-American astronomer Gerard P. Kuiper.

During that time of explosive discovery, Luu made a prophetic remark in *Astronomy* magazine about the new evidence: "The confirmation of the Kuiper belt changes our perception of the solar system. What we thought of as a planet is probably just the biggest member of a rather large population of objects." She was thinking of tiny Pluto. Smaller than our Moon, it had always been an oddball when compared with its gas-giant neighbors—Jupiter,

Saturn, Uranus, and Neptune. More ammunition arrived when Caltech astronomer Michael E. Brown announced in 2005 that he and his colleagues had found an object in the belt of the same size range as Pluto (which is around 1,400 miles wide), but with roughly a third more mass.

Brown's newfound body was eventually dubbed Eris, after the Greek goddess who personifies strife and discord. It was a fitting name,

Many a child (and adult) was horrified when the number of planets in our solar system dropped from nine to eight. It means the Italian-menu formula for remembering their order is out: instead of "My Very Educated Mother Just Served Us Nine Pizzas," we have "My Very Educated Mother Just Served Us Nachos." A banquet of pepperoni and cheese has been reduced to an appetizer.

Since the eighteenth century, we've been accustomed to astronomers adding planets to our solar system, not subtracting them: first Uranus in 1781, followed by Neptune in 1846. It seemed an unprecedented move for astronomers to take one away: the planet found by Lowell Observatory astronomer Clyde W. Tombaugh and greeted with such fanfare in 1930. Pluto, we hardly knew ye. But this is not the first time the solar system has undergone a substantial reconfiguring. Another planet once came and went in a similar manner—two centuries ago.

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Ever since Johannes Kepler, in the early 1600s, was able to link a planet's orbital period (the time it takes to round the Sun) to its orbital radius, astronomers sought an underlying pattern to the various distances of the planets from the Sun. In 1766 the Prussian scientist Johann Daniel Titius developed an elaborate mathematical scheme (based on earlier

STEVEN R. BLACK, AFTER BOLE, "ON THE NEW EIGHTH MAJOR PLANET DISCOVERED BETWEEN MARS AND JUPITER"

Planet	Predicted mean distance from Sun	Observed mean distance from Sun
♀ Mercury	387 units	387
♀ Venus	$387 + 293 = 680$	723
⊕ Earth	$387 + 2 \times 293 = 973$	1,000
♂ Mars	$387 + 4 \times 293 = 1,559$	1,524
Probable planet between Mars and Jupiter	$387 + 8 \times 293 = 2,731$	
♃ Jupiter	$387 + 16 \times 293 = 5,075$	5,203
♄ Saturn	$387 + 32 \times 293 = 9,763$	9,541
♅ Uranus	$387 + 64 \times 293 = 19,139$	19,082

Defining the observed distance from the Sun to Earth as 1,000 "units," an 1802 table by Johann Bode gives the distance from the Sun to Mercury as 387 units. A series of regular calculations based on Mercury's distance yields a close approximation of the distances from the Sun to the other planets known at the time, with one apparent gap.

because this groundbreaking work caused the International Astronomical Union to revamp the solar system's membership. By 2006 Pluto was demoted in status to "dwarf planet," no longer in the big time but simply one of the larger members of the Kuiper belt, like Eris. For their pioneering roles in this transformation of the solar system, Jewitt, Luu, and Brown were awarded the 2012 Kavli Prize in astrophysics, a prestigious biennial honor that comes with a cash award of \$1 million.

work by Oxford professor David Gregory) that appeared to account for the planets' positions. Six years later, a self-educated astronomer soon to be a professor at the Berlin Academy of Sciences, Johann Elert Bode, drew attention to the pattern in a new edition of a popular book on astronomy that he had written, which led to the rule becoming known as "Bode's law." The one shortcoming of the law was that it didn't account for an apparent gap between Mars and Jupiter, where it predicted an intermediate planet should appear.

When the planet Uranus was discovered at the very distance from the Sun that continued the sequence beyond Saturn, the sway of Bode's law (though not based on any physics) became near-mystical, immediately emphasizing the yawning gap between Mars and Jupiter. "Can one believe that the Creator of the Universe has left this position empty? Certainly not!" declared Bode. The success with Uranus encouraged astronomers throughout Europe to join forces to discover the planet everyone was sure was missing beyond Mars. The team jokingly referred to itself as the "celestial police," dividing the sky into twenty-four zones, so each could be thoroughly explored by one of the team.

Meanwhile, the discovery of an object orbiting in the "gap" was serendipitously made by one of the astronomers the "police" had intended to enlist—though he didn't know it. Working from a new observatory he had founded in Palermo, Sicily, the monk Giuseppe Piazzi was assembling a star catalog, the most accurate in its day. On the evening of New Year's Day in 1801 he routinely measured the position of a star in the constellation Taurus, the Bull. "The light was a little faint, and of the color of Jupiter," he reported, "but similar to many others which generally are reckoned of the eighth magnitude. Therefore I had no doubt of its being any other than a fixed star."

But, following his customary

procedure, Piazzi measured the star again the next night and found to his surprise that it had shifted. Over subsequent nights, he kept track of its movements and saw that its path was not elongated, like a comet's, but rather more circular. Privately, he wondered whether it might be the long-sought lost planet. "Since its movement is so slow and rather uniform," he wrote a colleague, "it has occurred to me several times that it might be something better than a comet. But I have been careful not to advance this supposition to the public."

By February, Piazzi was unable to continue his observations because the object was lost in the glare of the Sun, but he communicated his find to other astronomers. Although they could not observe the newfound body, the noted German mathematician Carl Friedrich Gauss was able to calculate its orbit from the limited data. That helped astronomers relocate Piazzi's object once it was again visible, on December 31, near the very spot in the constellation Virgo, the Virgin, that Gauss had computed. More than that, its orbital radius closely matched that predicted by Bode's law.

Piazzi named the object Ceres Ferdinandea (Italian for "Ceres of Ferdinand"), in honor of the patron goddess of Sicily and his own patron, King Ferdinand IV of Naples and Sicily. Bode excitedly wrote a paper in 1802 trumpeting the discovery (and not forgetting to crow about his own role in the endeavor): "Piazzi had, indeed, here discovered a very extraordinary object. It was most probably the eighth major planet of the solar system, which already thirty years before I had announced between Mars and Jupiter, but which until now had remained undiscovered." Bode published a table updating his concept [*see table on opposite page*].

Ceres's reign as a major planet, though, was a bit shorter than Pluto's. William Herschel, using his large telescope in Great Britain, was quickly able to discern that Ceres was smaller than our Moon. And

Heinrich Olbers, a German physician and accomplished amateur astronomer, soon found a similar object in the same region, which he christened Pallas. Over the next five years, two more, named Juno and Vesta, were found. Being hundreds rather than thousands of miles in diameter, these newfound objects appeared starlike ("asteroidal") to Herschel in his telescope, so he suggested the name *asteroid* to describe this new class of objects. It took some time, though, for all astronomers to fully apply this term. As late as 1866, the Berlin Observatory's annual yearbook continued to list the first four asteroids as major planets. Other observatories called them "minor planets" for a while.

In the nineteenth century it was believed the asteroids were the remains of a former full-sized planet that had somehow disintegrated in the distant past. Today it is known they are a field of debris—tens of millions of fragments of planetesimals that failed to coalesce into a major planet owing to the gravitational tugs of nearby Jupiter, and that then randomly smashed into one another like cosmic bumper cars. Ceres was a protoplanet that failed to grow up.

But no tears need to be shed for this celestial goddess. At the same time that Pluto got demoted in 2006, Ceres got re-promoted. As it is the largest object in the asteroid belt (containing a third of the belt's entire mass) and rather round, with a diameter of about 590 miles, the International Astronomical Union reclassified it as a dwarf planet, the sole one in the belt. It's the queen of the asteroids, majestically orbiting the Sun once every 4.6 years. NASA's Dawn spacecraft is scheduled to visit it in 2015.

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