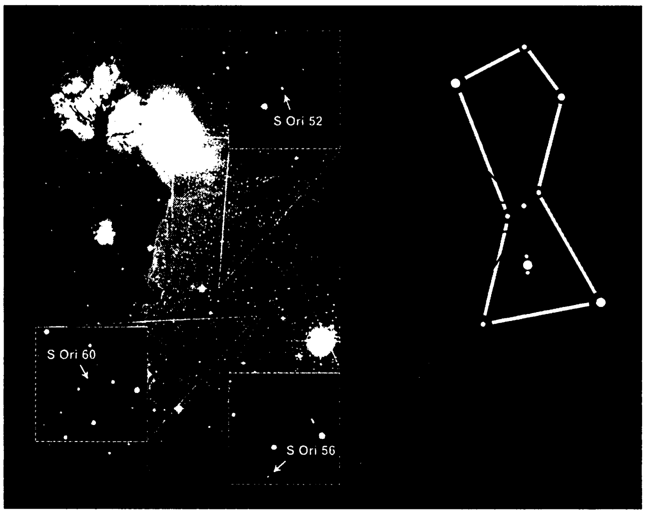
PLANETARY SCIENCE

Giant 'Planets' on the Loose in Orion?

Strange, dim objects in the constellation Orion have left astronomers hunting for words. In a young star cluster perched near Orion's belt, a team at the Astrophysics Institute of the Canary Islands has spotted nearly a score of what appear to be balls of gas several times as massive as the planet Jupiter. Unlike planets, however, the objects —described on page 103 of this issue—are celestial free agents, drifting through the cluster rather than orbiting stars. Astronomers disagree about how they got there and what to call them. Are they "a new kind of giant planet," as their discoverers would have it? Or are they something else entirely —perhaps unusually puny brown dwarfs?



Rogue Jupiters? New observations of a young star cluster in Orion reveal 18 free-floating red objects, including the three shown here, that resemble giant planets with masses five to 15 times that of Jupiter.

Brown dwarfs, objects lighter than 75 times the mass of Jupiter, never grow hot and dense enough to ignite stable furnaces of hydrogen fusion at their cores. Rather, some glow feebly by fusing atoms of deuterium, a heavier and rarer isotope of hydrogen that requires less energy to burn. Below 13 Jupiter masses, dwarfs lack enough heft to sustain even that reaction. Instead, they shed the heat produced by their gravitational contraction until they fade to invisibility.

Recent surveys of other young star clusters indicate that such small objects are common. For example, astronomer Joan Najita of the National Optical Astronomical Observatories in Tucson, Arizona, and her colleagues reported in the 1 October issue of the *Astrophysical Journal* that the cluster IC348 in Perseus is richer in low-mass brown dwarfs than in high-mass ones. The team's Hubble Space Telescope observations captured objects as low as 15 Jupiter masses, but Najita's data hint that the trend continues to even smaller sizes. "The process that makes stars shows no sign of pooping out at these lower masses," she says.

Now, the latest study strengthens that suspicion. The Canary Islands team, led by astronomer Maria Rosa Zapatero Osorio, used long exposures with two Spanish telescopes to find 18 faint, red objects in the Sigma Orionis cluster. The team's analysis suggests that most float freely amid the cluster itself rather than in the background or foreground. Spectra of three of the objects from the Keck telescopes in Hawaii revealed temperatures of 1700 to 2200 kelvin.

Because the Sigma Orionis cluster is so young—just 1 million to 5 million years old, according to other studies—the team calculated that the objects must be very small indeed to have cooled off so quickly from the heat of their formation. By examining three models of how such objects may evolve, the researchers derived a range of five to 15 Jupiter masses for its quarries. "Less massive objects cool down very rapidly and would be too faint for our survey to detect," says Zapatero Osorio, who is now at the California Institute of Technology in Pasadena.

Other astronomers find the detections convincing. But they caution that it's not clear whether the stellar evolution models are valid for such tiny objects. "None of the models have been tested at very low masses and very young ages," says astronomer Gibor Basri of the University of California, Berkeley. If the models are shaky, Zapatero Osorio's objects may not be so lightweight after all.

Large or small, the cosmic rovers still might not qualify as planets. Most astronomers reserve the "p word" for bodies that form within a planetary system and orbit stars, says theorist Alan Boss of the Carnegie Institution of Washington in Washington, D.C. "They should call them 'planetary-mass brown dwarfs,' " says Boss, whose calculations show that, depending on circumstances, clouds of molecular hydrogen may either condense into full-fledged stars or fragment to form dwarf objects as small as three Jupiter masses. The same semantic umbrella should cover all such bodies, he maintains.

However, Basri and theorist Jack Lissauer of NASA's Ames Research Center in Mountain View, California, point out that Boss's way of distinguishing "planets" and "stars" is imprecise, too. Both form in accretion disks, they note. Furthermore, gravitational tugs from other massive planets or stellar interlopers can eject large planets from a system. A few such wanderers might be drifting through Sigma Orionis, Lissauer says. "We won't be able to figure out how every object formed," he notes. "Classifying planets solely on some useful basis like mass or lack of fusion in their cores has some merit."

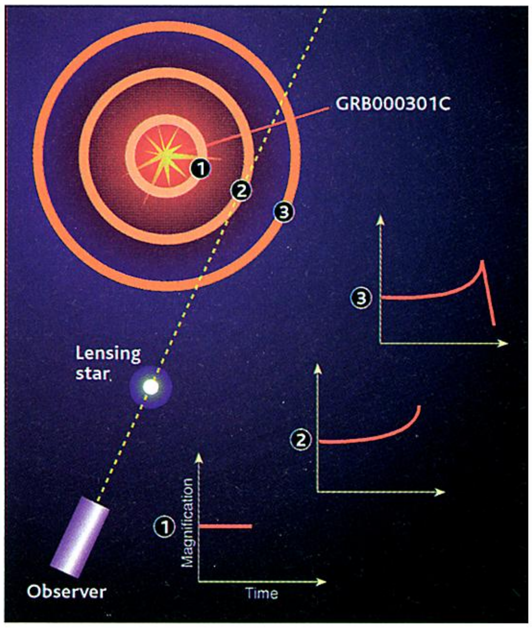
Najita thinks the name debate is inconsequential compared with the science at hand. "We should use observations of all of these low-mass objects to learn new things about how planets and stars form," she says. "That's the real strength of these studies."

—ROBERT IRION

ASTROPHYSICS

Lucky Star Sheds Light On Gamma Ray Burst

Spill a clear drink on this page, and the drops of liquid will magnify the letters into a jumble of swelling arcs and dots. Astrophysicists think an analogous effect deep in space has helped them glimpse a much harder-to-see letter: the expanding O left by the afterglow of a distant gamma ray burst. A well-placed star, they believe, accidentally acted as a telescope, focusing light from the O so that more



Distant lens. An unseen star may have amplified light from gamma ray burst GRB000301C.

CREDITS: (LEFT) GABRIEL PEREZ/INSTITUTO DE ASTROFÍSICA DE CANARIAS; (RIGHT) MODIFIED FROM A. LOEB/HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS of it reached Earth. The resulting "microlensing" may have given scientists their first direct evidence that gamma ray bursts (GRBs) blow fiery bubbles into the cosmos.

"This is an amazing confirmation of a surprising prediction," says astronomer Peter Garnavich of the University of Notre Dame in Indiana, part of the team that made the discovery. To prove it, though, Garnavich and colleagues must show that the lensing star exists, and that won't be easy.

About once a day, a sudden explosion of gamma rays pours down on Earth from a random corner of the universe. Theorists believe the initial explosion powers an expanding spherical shock wave that crashes into the surrounding gas at nearly the speed of light. The collision lights a cosmic fire at the sphere's surface that, if you could see it, would look like a glowing ring. As the wave expands and the fire fades, the afterglow changes "color" from x-ray to optical light to radio wave. Although a worldwide network of telescopes has captured the rapidly fading glow of about 20 bursts in the past 3 years, none has seen the predicted ring of fire. That's no surprise, theorists say; such a ring would be at least 1 million times too small to resolve with the most powerful telescopes.

Last March, the gamma ray burst GRB000301C changed all that. The burst occurred about 10 billion light-years away, in the constellation Corona Borealis. Routine follow-up observations with radio and optical telescopes caught an unexpected sudden brightening in the afterglow's otherwise smooth fade-out. "Since gamma ray bursts are usually so well behaved, this really stood out," says radio astronomer Dale Frail of the National Radio Astronomy Observatory in Socorro, New Mexico. Frail and his colleagues speculated that the shock wave brightened when it overtook a lump of interstellar gas.

Then, a closer look at the compiled radio and optical frequency data by Garnavich and by Kris Stanek of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, turned up a surprise: Within the small observational uncertainties, brightness increased evenly at all frequencies. Shock waves colliding with interstellar gas rarely produce such achromatic changes. Instead, Garnavich, Stanek, and CfA astrophysicist Avi Loeb argue in a paper accepted for publication in the *Astrophysical Journal Letters*, part of the expanding ring must have passed behind a star located exactly between Earth and the ring itself. When that happened, the star's gravity would have focused the light from the ring, bending each frequency by the same amount while increasing the intensity by a factor of 2—precisely as Loeb and his student Rosalba Perna had predicted in a 1998 paper. The duration of the flare-up implies that the width of the ring is between 7% and 20% of its radius, Stanek says.

The data are too sparse to prove unambiguously that microlensing caused the curious brightening of GRB000301C, Frail says, and there is no way to go back and get more. "Gamma ray bursts are a one-shot deal," he laments. Help may come from the HETE-2 orbiting GRB observatory, scheduled for launch on 7 October, which is expected to spot dozens of new afterglows a year. With more observations, says Princeton astrophysicist Bohdan Paczyński, GRB microlensing may become as well established as so-called galactic microlensing, in which one star brightens achromatically as it passes behind another. "At first, everyone called them *candidate* microlensing events," Paczyński says. "But after many more were discovered, they stopped saying 'candidate.'"

—MARK SINCELL

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DEPARTMENT OF ENERGY

Science Wins Out in Latest Budget

Science has emerged a winner in this year's struggle over the Department of Energy's (DOE's) budget, erasing fears earlier this summer of severe cuts in several high-profile programs. Congress this week gave the agency's civilian science programs a 13% boost, to $3.2 billion, slightly more than the Administration had requested. The $24 billion bill also includes the extra cash needed to keep the world's largest laser project on track and restores funds that the directors of DOE's national laboratories can award to hand-picked projects. Even a threatened veto by President Clinton due to an unrelated issue is not expected to alter the research numbers.

Such an upbeat result seemed unlikely just a month ago, after both the House and the Senate approved budgets that would have punched major holes in research programs at DOE, the federal government's third-largest funder of basic research. The House, for instance, had severely cut funding for the Spallation Neutron Source (SNS), a $1.2 billion materials science accelerator that DOE is building at the Oak Ridge National Laboratory in Tennessee. The Senate, in turn, fully funded the Administration's $279 million request for SNS, but only by cutting the budgets for high energy and nuclear physics. The shortfalls prompted an all-out lobbying push by a coalition of university presidents and scientific societies.

That campaign, along with projections of a growing federal budget surplus, convinced legislators to match or exceed the Administration's request in nearly every field. The spallation source received its full request. A thicker wallet also paid for nearly $60 million in academic pork-barrel projects, including $3 million for a new nanotechnology research center at Notre Dame University in South Bend, Indiana, and $2 million for a Digital Millennium Center for high-speed computing at Tulane University in New Orleans, Louisiana. There is also $11 million earmarked for research in functional brain imaging at locations to be determined.

Even the troubled National Ignition Facility (NIF), a $3.8 billion laser under construction at Lawrence Livermore National Laboratory in California, escaped the ax. Responding to revelations of mismanagement and massive cost overruns, the Senate had voted earlier to deny the Administration's request for a $135 million increase this year for the megaproject, which will allow researchers to study nuclear weapons without testing them and to explore the feasibility of fusion energy (*Science*, 18 August, p. 1126). But the final bill gives NIF $200 million, just short of the $210 million request. Congress did attach some major strings, however, including a directive to commission the National Academy of Sciences to review the project, a requirement that Livermore pay for some of the overrun out of its own operating budget, and a DOE study of scaling back the project. Livermore chief Bruce Tarter said he was "very pleased" that the laser had survived.

Other lab chiefs were buoyed by the restoration of their internal grant programs, officially known as Laboratory Directed Re-

DEPARTMENT OF ENERGY

Program	2001 Request	Funding	% annual change
Office of Science	$3151	$3186	+13
High-Energy Physics	715	726	+3
Nuclear Physics	370	370	+4
Basic Energy Sciences	1016	1013	+30
Fusion Energy	247	255	+3
Biology and Environment	445	500	+15
National Ignition Facility	210*	200	NA
Spallation Neutron Source	279	279	+180

* Includes $135 million supplemental request to cover construction delays and cost overruns.