ASTRONOMY

Tooled-Up Amateurs Are Joining Forces With the Professionals

Hobbyists who love the night sky are finding that their skills, and telescopes, are in demand with academic astronomers

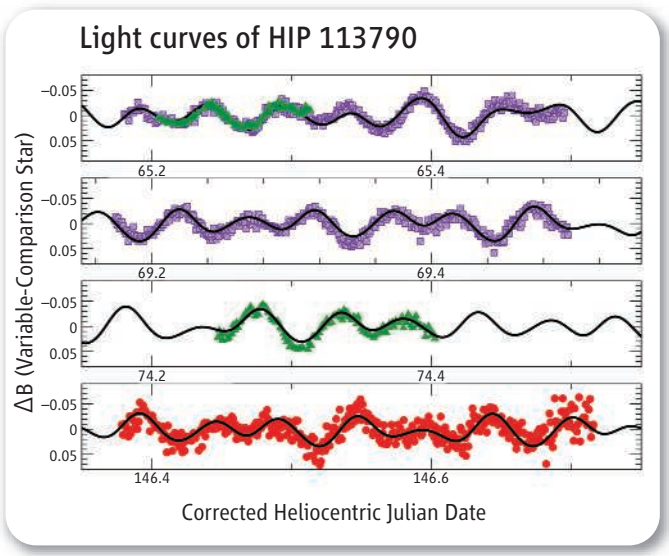
BARCELONA, SPAIN—By day, Antonio Garrigós-Sánchez seems like an ordinary guy. The proud 46-year-old father of two girls works as a technician at a printing firm. But by night, he transforms. After sundown, Garrigós-Sánchez retreats to his underground lair, a basement office that would not be out of place at NASA headquarters. The walls are lined with shelves of instruments, journals, astronomical reference books, and stacks of data backup disks. And with a few clicks at the computer on his desk, Garrigós-Sánchez is staring into deep space.

Behind the Garrigós-Sánchez domicile stands an observatory he built from off-the-shelf components. Through the open dome of the cottage-sized building points a telescope as big as a torpedo. Night after night, guided by his computer, it collects light from a zoo of strange celestial objects and records its data on disk. Garrigós-Sánchez doesn't do this only for the joy of watching the night sky; his data are vital for several ongoing academic research projects, and his name appears as co-author on a string of peer-reviewed papers.

Among scientific fields, astronomy may be the last one in which amateurs can stand shoulder to shoulder with professionals and expand the envelope of knowledge. In some cases, they are even outcompeting professionals for research grants. The past decade has seen a renaissance in amateur astronomy due to technological innovations and cheaper components. Basic research can only benefit by tapping into this resource, says Joseph Patterson, a professional astronomer at Columbia University. "The sum total of ingenuity and energy among the world's amateur astronomers vastly exceeds that of professionals."

Cheap tools, long nights

Amateur astronomers are quick to point out that their research has a long pedigree. Many astronomical pioneers were rich men who liked to play with telescopes. William Herschel was an organist and composer in the English town of Bath when, in 1781, he discovered Uranus. In North America, amateurs began exchanging observations and theory with professionals as early as 1868 with the founding of the Royal Astronomical Society of Canada. But things really got cooking in 1911 when the American Association of Variable Star Observers (AAVSO) started pooling data in what has become the world's largest database of amateur astronomical observations. It was founded at Harvard University to ensure that the observations made by amateurs would not be lost.



Top quality. Data like these observations of a variable star from amateurs are bread and butter for professional astronomers.

AAVSO now logs about 1 million observations per year from amateurs in 45 countries.

The scale of such amateur scientific efforts is unknown in other fields. (Imagine 2500 volunteer biologists studying fruit fly development with state-of-the-art equipment in their own homes.) The AAVSO amateurs co-authored 30 peer-reviewed papers last year alone, and the association usually holds several active research grants at any one time. Dozens of other networks have sprouted up in the past decade. Garrigós-Sánchez is part of a Barcelona-based group called AstroGea that links amateurs with professional astronomy projects throughout Europe. The quality of these backyard observatories is such that professional astronomers are regular users.

There are several reasons for this blossoming, says Richard Fienberg, editor of *Sky & Telescope* magazine. "But the biggest breakthrough was the CCD camera," he says. "It immediately allowed us to see objects 10 times fainter with the same telescopes."

The CCD, or charge-coupled device, camera has become the sine qua non of astronomical data collection since its invention 3 decades ago, as well as making possible cheap video cameras and digital photography. CCD cameras allow astronomers to convert photons into data much more efficiently. In traditional photography, photons trigger a chemical reaction in the film that, after several steps of development, produces metallic grains that add up to an image. But in a CCD camera, incident photons directly create an electrical pulse in a circuit that can be recorded on a computer as a pixel. The boost in efficiency—CCD cameras detect 70% of photons compared with film's 2%—suddenly turned humble backyard telescopes into "very powerful tools," says Fienberg, who was finishing his astrophysics Ph.D. at Harvard in the 1980s when CCD cameras were first coming into mainstream use among professional astronomers. Cheap mass-production put CCD photography in the hands of amateur astronomers by the early 1990s.

The new bounty of digital data has required heavy-duty computing, and amateurs have played a role here as well. An amateur-scripted program called MaxIm DL controls telescope positioning and the CCD camera and processes the data. "The quality of this software is superb," says AAVSO director Arne Henden, "and it is heavily used by professionals." The program is one among many, he says.

The other key breakthrough was online communication, because it enables observers to react quickly to fast-changing events. "The Internet is key to the blurring of the amateur-professional dividing line," says Henden. A recent example is the observation of an extremely rare pair of stars, known as V455 And (for "Andromedae"), in which a white dwarf is sucking matter from its partner, a brown dwarf. Professionals have been waiting for the white dwarf to gather enough nuclear fuel to become "cataclysmic," releasing a

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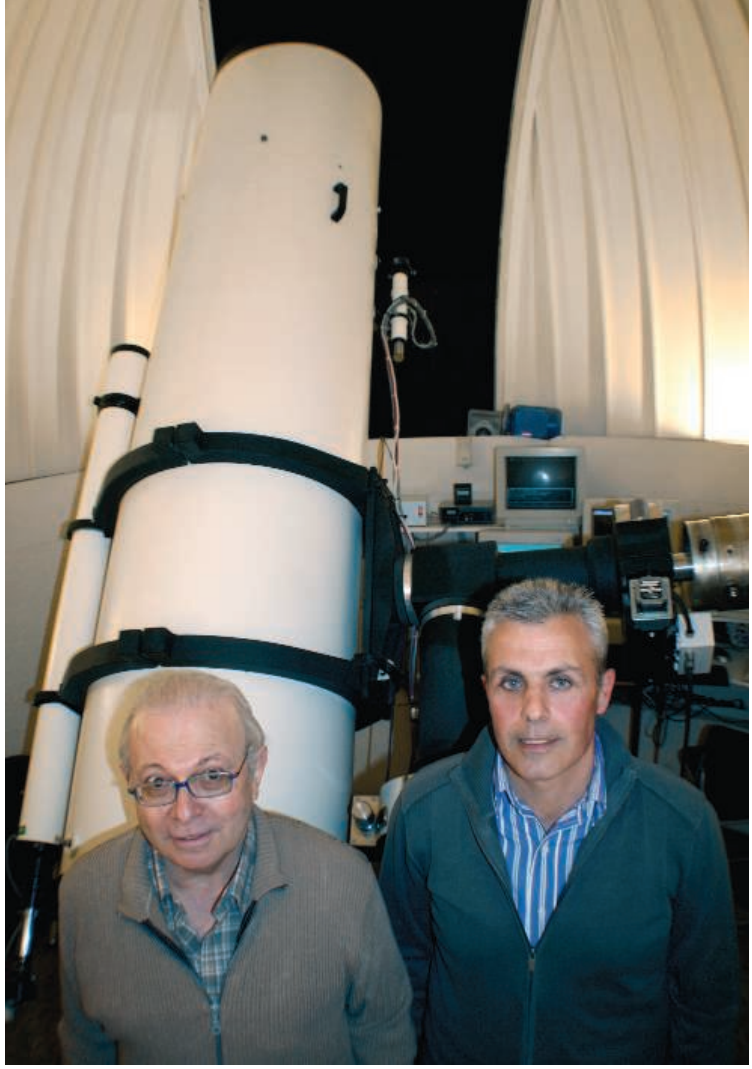
sudden explosion of light that provides valuable data on stellar evolution. The outburst was not expected for decades, but it happened on 5 September. A Japanese amateur spotted it and sent out a notice online, and amateur telescopes around the world swiveled to capture the brief event. "Amateurs are leading the observational studies," says Henden, and "there will be many important papers that will come from this event."



For the love of it. Antonio Garrigós-Sánchez (*right*) in a homemade observatory. Backyard facilities such as these are luring professional astronomers into research collaborations.

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Redefining amateur

But are amateur astronomers aware of how their observations translate into real science? They are, says Fienberg. "It's amazing how well some of them follow the field."

Take Brian D. Warner, for example. (The initial distinguishes him from a professional astronomer in South Africa.) "I got my first CCD in 1992," says Warner, who was working as a computer programmer and television reporter in Colorado Springs, Colorado, at the time. He is part of a network of more than 1000 international amateurs scrutinizing our solar system's minor planets—the asteroids and their ilk, most of which orbit beyond Mars. Many are as big as mountains, but just finding them in the inky blackness was a feat. Mapping the distribution of these bodies is needed to constrain models of how the solar system evolved. Armed with CCD cameras, amateurs became latter-day Galileos, reporting hundreds of previously unidentified astronomical bodies.

That bonanza came to an end when the professionals caught up in 1997 with the first full-sky digital surveys. "But that just changed the game," says Warner. Instead of identifying new minor planets, amateurs focused their efforts on characterizing them, making repeated observations to reveal their size and rotational speed and whether they are orbited by their own tiny moons. And this is where Warner and others got deep into the science.

A burning question is how minor planets acquire their own satellites. The prevailing theory in the 1990s held that if a minor planet swings close to an enormous body like Mars, the pull of its gravity can break a chunk free from the small body's surface. To test that theory, Warner searched for dancing pairs of bodies far beyond the reach of the major planets. Over the past 3 years, he has identified five pairs. The discovery helped rule out the tug-of-gravity theory, and a new explanation—that solar heating causes rotational acceleration that flings chunks off—made the cover of *Science* last year (24 November 2006).

Warner is sheepish about calling himself an amateur these days, because he has earned a master's degree in astronomy from James Cook University in Townsville, Australia, and is a full member of the American Astronomical Society (AAS), an organization generally open only to professional astronomers, granted on the basis of his published work. But he still considers himself the amateur half of a collaboration that began at a minor planet conference in 1999 when he met Alan Harris, a planetary astronomer at the Space Science Institute in Boulder, Colorado. Warner himself won grants from the U.S. National Science Foundation and NASA this year. One of his missions is to catalog the spin properties of all known near-Earth objects, based on his observations and those in the literature. Aside from the value to basic science, the project "does have that extra Hollywood aspect of helping to prevent a global catastrophe," says Warner. Any one of thousands of nearby asteroids could devastate the planet on impact.

Warner's achievements in the field make him stand out, but he's not unique. The number of amateur-professional research collaborations has exploded simply because "professional astronomers need them," says Patricia Lampens, an astronomer at the Royal Observatory of Belgium in Brussels. Her own field of research, variable stars, is a case in point. This class of stars is mysterious because they grow brighter and fainter periodically. To tease apart the many causes of variability, data must be collected continuously throughout a star's cycle, which can range from minutes to years in duration, to obtain a "light curve." Getting just a single night at one of the major professional telescopes is like winning the lottery, but amateurs have the "luxury" of observing whenever they want, she says. Amateurs such as Garrigós-Sánchez "deliver very high-quality data" on the same target over "many weeks or even months" for free. The stellar light curves cataloged by AAVSO are of similar quality.

For professionals to take full advantage of this free resource, some sort of dating agency is required. "What's needed is an efficient system to connect professional astronomers one-to-one with well-equipped amateurs," says Fienberg. He is now helping to set up a "pro-amateur registry" through AAS. Profiles of international amateurs will include their telescope specifications, observing experience, and e-mail addresses. And professional astronomers will post details about their research projects and what kinds of observations they seek.

The registry is bound to blur the amateur-professional line further. When it comes to astronomy, says Donald Kurtz, an astronomer at the University of Central Lancashire in Preston, U.K., "the term 'amateur' should be taken in its original French meaning": a "lover" of astronomy, not necessarily lacking in skill.

–JOHN BOHANNON

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