Stones from the sky

Shooting Stars

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Space agencies like NASA spend millions of dollars trying to obtain samples of extraterrestrial matter. Nonetheless, several million particles of interplanetary dust actually fall into our atmosphere every day - how can such precious cosmic material be recovered?

Obtaining matter of extraterrestrial origin has long been one of the greatest wishes of the astrophysicists and geologists who study the history of the Solar System's formation. The Apollo mission retrieved more than 380 kilograms of lunar matter, a true bonanza for scientists, yet those samples long remained the last fragments of cosmic matter brought to Earth. Quite recently, three ambitious space missions were meant to change that. The first was Genesis in 2001-2004, which captured solar wind particles and aimed to transport them back to Earth in a special parachute-dropped capsule, yet ended in fiasco due to parachute failure. The next project was Japan's Hayabusa mission, with the objective of collecting samples from the Itokawa planetoid and bringing them back to Earth. Unfortunately, it most likely never managed to collect its samples. Success only came with the third mission, when the Stardust probe passed through the tail of comet 81P/Wild 2, captured many of its particles, and brought them back to Earth in 2006.

These examples show that agencies like NASA are prepared to spend even hundreds of millions of dollars to obtain samples of matter from space. We forget, however, that the simplest solutions often turn out to be the cheapest and best. Several million particles of interplanetary dust actually fall into our atmosphere every day. Many of them are the size of a grain of sand and burn up at a height of some 80-100 km, producing beautiful "shooting stars." But a small number, those more than several kilograms in mass, can produce the *bolide* or "fireball" phenomenon, shining with a brightness comparable to that of the full Moon and/or reaching the Earth's surface in the form of meteorites.

D. Dorosz

Photo of a fireball from the Taurid meteor shower, several times brighter than the full Moon

A. Olech

Photo of a fireball visible over Warsaw on the night of 4–5 July 2006

Such matter from space offers an invaluable source of information about the solar system's beginnings. The problem is that most bright bolide phenomena go unrecorded, which entails a loss of scientifically valuable information and material. Time likewise works against us: the most commonly occurring meteorites are rocky, quite quickly succumbing to erosion and coming to look like ordinary stones.

Seeking stones from space

It is no wonder, therefore, that photography has long been harnessed to observe meteors, trying to capture the greatest number of these phenomena on film. However, the techniques required are not simple. In order to identify an object's orbit, its trajectory through the atmosphere, and the landing site of any potential meteorite, a fireball occurrence has to be observed from at least two locations tens of kilometers apart. The first to use such a method on a large scale was the well-known comet and meteor researcher Fred L. Whipple, launching a base review of the sky at Harvard University in 1939–1951, based on Schmidt photographic cameras.

After that project finished in 1951, Whipple's work was continued in Czechoslovakia by astronomers from the Ondřejov observatory. A breakthrough came for the Czechoslovak (and European) fireball observation network on 7 April 1959, when the Czechoslovak stations registered a bolide occurrence 250 times brighter than the full Moon. Photographic observations allowed its orbit and potential landing site to be identified, enabling four meteors that had fallen in the vicinity of Příbram to be rapidly recovered.

The Příbram meteorite helped the European astronomic community realize it would be worthwhile to invest in a fireball observation network covering the broadest possible area. In 1963, therefore, the Czechoslovak stations were transformed into the embryo of the European Fireball Network, which now encompasses more than 30 photographic stations scattered through such countries as the Czech Republic, Germany, the Netherlands, Austria, Slovakia, Belgium, and Switzerland.

The Polish Fireball Network

The statistics of the Czech system, currently the best, show that an average of 32 fireballs a year are registered in the country's skies, with one of them capable of pushing through the atmosphere and landing as a meteorite at an identifiable location. Since Poland's area is

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The PF030405a "Krzeszowice" fireball was registered by as many as five stations of the Polish Fireball Network on 3 April 2005. It flared with a brightness slightly less than that of the full Moon. Unfortunately its speed was so great that it completely burned up in the atmosphere, not managing to reach the Earth's surface as a meteorite

four times greater than the Czech Republic's, one can easily calculate that our country's lack of a fireball network leads us to miss observing some 100 bright fireballs plus 1-2 possibly recoverable meteorites per year.

Yet there is one serious obstacle to developing a comparable system in Poland. The Czech network's fully automated photographic stations employ high-caliber optoelectronic instruments, able not only to very accurately trace the route of an object across the night sky, but also to precisely pinpoint its angular velocity and time of appearance, to plot changes in its brightness, and to register any potential sound effects. The cost of each such station can run well into the tens of thousands of dollars. Efficiently covering Poland's territory would require more than 30 such stations. Given the current research funding situation in Poland, a project of this sort is virtually impossible.

Fortunately, professional astronomy has nearly always eagerly drawn upon the assistance of amateur astronomers. One of the world's most active organizations of meteor observation enthusiasts is the Comet and Meteor Workshop (PKiM) in Poland - the present author has had the pleasure of being involved in this organization for years, and of serving as its president. Assisted by undergraduate and doctorate students from the PAN Astronomical Center in Warsaw and the Warsaw University Astronomical Observatory, individuals involved in the PiKM jointly established a Polish Fireball Network (PFN) in 2004.

Possessing meager funding, we of course had to adopt a completely different *modus operandi* than the Czech researchers, yet we were helped by state-of-the-art electronics. When the Czech network was being set up nearly half a century ago, one could scarcely imagine using any technique for registering fireball occurrences other than photography. Nowadays, CCTV cameras used in industrial security systems offer a good low-cost solution. Pure chance likewise worked in our project's favor: one of the PKiM's most active members is actually a security equipment dealer by trade. That fact enabled us to test a number of cameras and lenses and to choose ones that were most suited to our needs. At the same time, this individual's contacts helped us secure funding for the PFN project from one of the leading camera and lens manufacturers, Siemens Building Technologies.

We made our first purchases back in 2004, and observations got moving at full steam in 2005. There are now more than a dozen stations in operation, managed by PKiM members. Each has 2-3 cameras with lenses taking in an angle of nearly 70 degrees, and each station is able to register meteors even 100 times weaker than the weakest ones the Czech system can register! Yet on the other hand, the resolution of the images obtained by our low-cost video cameras is considerably below what the Czechs attain with large-format Ilford photographic plates.

Our cameras monitored the sky for a total of more than 10,000 hours in 2005, a figure that increased to more than 20,000 in 2006.

First successes

Our network can already boast its first successes. One of the brightest phenomena so far observed was the Krzeszowice fireball, registered on 3 April 2005 by as many as five of our stations, with a brightness slightly less than that of the full Moon. This meteor dropped into our atmosphere at a speed of 28.85 km/s and began to shine at a height of 98.3 km. It continued along a path 115 km long, ending at a height of 37.9 km and breaking up into several fragments along the way. Unfortunately its velocity was just a bit too fast for it to reach the ground as a meteorite. It may be interesting to note that this meteor appeared nearly exactly one day after Pope John Paul II's death, and the trajectory calculated on the basis of our observations indicates that if it had made it through the atmosphere, it would have landed in the vicinity of the pope's birthplace, Wadowice.

A second interesting finding came when our network noted a period of increased meteor activity around 20 August 2005, with three very bright occurrences registered over three consecutive nights. Moreover, these objects seemed to originate from the same place in the sky, suggesting a physical link between them and the existence of a new stream rich in large particles.

Yet another noteworthy achievement involved our observation of an unexpected outburst of early Perseid activity - a finding that demonstrated the power of video observations. Video cameras are also sensitive to the near infrared, meaning that they can observe the heavens even through a thin cloud cover, or just after sunset or just before sunrise, times when the sky is too bright for visual or photographic observation. Without such video techniques, this surprise outbreak of early Perseid meteors observed on the morning of 14 July 2005 would have passed unnoticed. Our cameras managed to register more than 100 Perseids, although usually only a few of them occur. This finding will undoubtedly contribute to the structural study of this well-known, interesting meteor shower.

For a project of this nature, having two years of operations under our belt essentially means still being in the trailblazing stage - especially since our project is based on new techniques, new equipment, and relies mainly upon the enthusiasm of amateurs. Nonetheless, in those two years we have managed to set up more than a dozen fully automated stations monitoring the skies on every clear night. Our first results are encouraging, although the PFN is still waiting to detect its first fireball occurrence ending in a meteorite reaching the ground. ■

Further reading:

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Photo of a bright meteor from the Perseid shower, with a high maximum, observed on the night of 11-12 August 2004