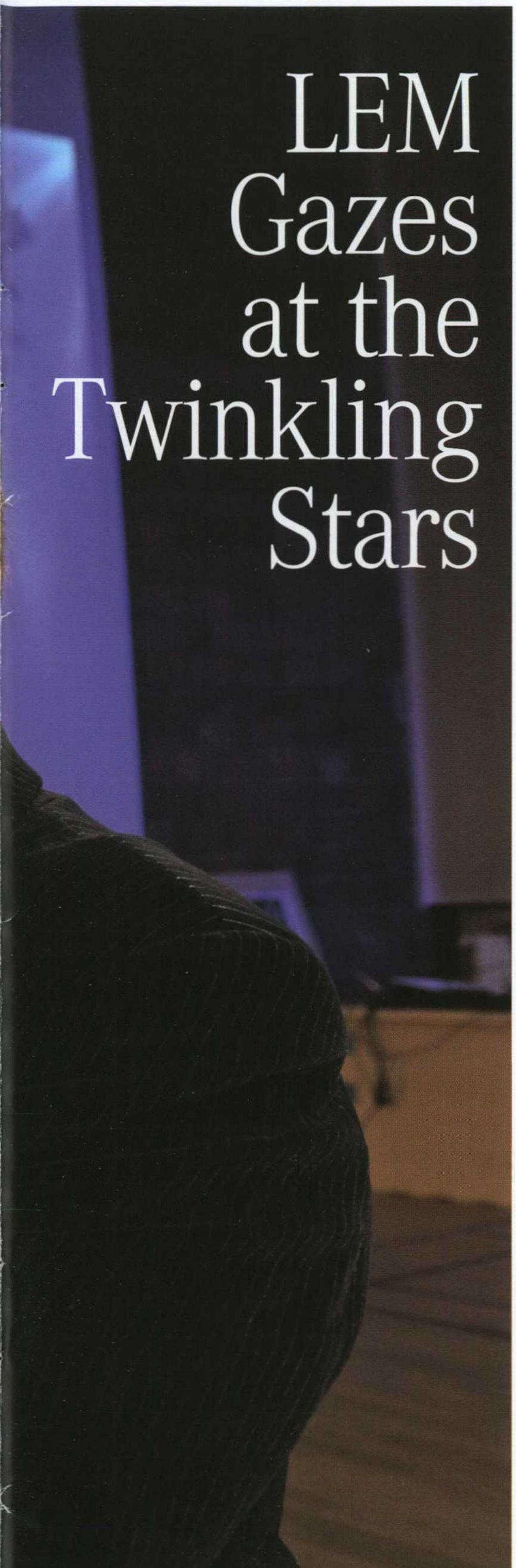
Interview with Prof. Paweł Moskalik



LEM Gazes at the Twinkling Stars

Academia: We are talking on 21 November 2013, an important day for Polish astronomy.

Paweł Moskalik: *Just so. Precisely at 08:10:11 Polish time, a Dnepr rocket was launched out of Yasny base in the Southern Ural, putting Poland's first scientific satellite BRITE-PL "Lem" into Earth orbit. BRITE is the name of an entire constellation of satellites. There will be a total of six: two from Poland, two from Austria (already in orbit), and two from Canada. As you might have noticed, these three countries all have the colors white and red in their national flags! (laugh)*

But that's obviously a coincidence. We joined the project, because we have our people in Canada. Prof. Sławomir Ruciński has been working there for many years. It was thanks to him that we got involved in the project early. Starting early, we had the time to obtain funding for Polish satellites.

Does this mean that you can sit back and relax?

No, this's just the beginning. Everything needs to be tested, set in motion, and calibrated. We must know the exact properties of that telescope. Of course, it was calibrated on the ground before launch, but no gear ever has the exact same properties in orbit as in a laboratory on the ground. After that, there will be time for the collection of research data. For the time being, the satellite has separated from the rocket as scheduled and we have established contact, so everything is going according to plan.

Where is it now?

It is orbiting the Earth at an inclination of 98 degrees and altitude of around 700 km. Its orbit cycle, or the time it needs to complete one orbit, is 99.5 minutes. It is visible from Poland every time it passes over. What I mean is radio visibility, because the satellite is too small to be spotted with the naked eye.

You established communications after several hours.

It started transmission immediately, we only needed to wait for it to pass over Poland to attempt to establish contact. We succeeded, although there were no guarantees. It's an important phase, because we've received confirmation that what we have out there in orbit is not 6 kg of junk but fully operable gear. Unfortunately, it sometimes happens that a rocket works well, but the satellite later doesn't respond and no one knows what is happening. And what's the point of having a satellite that you can't communicate with?

Many people were involved in the project.

Yes, it took over a year and half to build the satellite. After that, it spent some time waiting to be launched. Many people were involved in those efforts. I'm waiting for data. This is because I'm an astrophysicist, not an engineer. For the engineers, this is their child, they spent a lot of time fine-tuning it, so it's a very exciting moment for them.

What are the tasks facing "Lem"?

Several months from now, it will be performing photometric tasks, which means measuring the brightness of stars. When seen from the Earth's surface, stars seem to twinkle. That's not because their brightness changes, but because of the turbulence in the Earth atmosphere. Some stars, however, exhibit intrinsic fluctuations, so their brightness varies, sometimes considerably, by a factor of 10 or even 100, but that's a rarity. Most of them change their brightness by a fraction of a percent. And these are the stars that we want to observe.

Why?

Variations in brightness are caused by star oscillations, or vibrations. We know that every object has its own tones of vibrations: a violin will sound different from a double bass, because they are built differently. Oscillation frequencies carry information about the internal structure of objects. The same holds true for stars. We roughly know the internal structure of stars, because we can observe their radiation. But it is emitted from the surface, so it carries no information about the interior of stars. If we want to examine what is happening *inside, say to follow the rotation inside the stars, we need to observe oscillations. Mathematically, this method is similar to those used in seismology. During an earthquake, a seismologist measures the tremors of the Earth's crust and analyzes them to draw conclusions about the structures deep inside the planet.*

Obviously, BRITE is not the first device facilitating such research. In addition to BRITE, there are three satellites that provide the photometry of stars, but these are very weak stars. Thanks to "Lem," we will be able to study the photometry of the brightest stars..

Is it not possible to conduct such measurements from Earth?

It is, but not with sufficient accuracy, again because of the atmosphere. The same fluctuations that cause stars to twinkle reduce the quality of observation. Aside from that, we simple can't see certain things from Earth. When the Kepler space telescope was launched four years ago, its purpose was to find planets other than Earth. But Kepler also performed photometric measurements of 100,000 stars in a small section of the sky in the constellation Cygnus. It took it just a month to discover a very interesting effect in RR Lyrae stars. Those stars had been observed from Earth for 100 years and no one had discovered that! But Kepler did, because it operated outside the atmosphere without interruption. When we work at a single site on the ground, we must break our observations during the day. Telescopes in space work without such breaks. A single BRITE satellite couldn't do that: it travels in low orbit, so it is obstructed by the Earth from time to time. But BRITE will be a constellation of six satellites. Put together, they will give us a chance to observe a single object almost without interruption.

But let us get back to the Kepler telescope.

Kepler is not ours. It is an American project that cost $600 million. A huge machine. Kepler data is publicly available; I have been working on it for several years. Those who know what to do with such information can find a lot of things there. Of course, BRITE will never do what Kepler did. They have different niches. But the stars we will be able to observe thanks to BRITE are too bright for Kepler to survey. Simply put, the detector would get burnt.

You've been also involved in the observations of the Whole Earth Telescope.

Yes, I have, for many years. The Whole Earth Telescope is an entirely ground-based project. It was invented by people observing pulsating white dwarfs, very old stars that have reached the end of their lifetime. All that is left is a burnt-out core, 99% of which is composed of oxygen and carbon, surrounded by a thin layer of hydrogen, helium, and some heavier elements. This layer can pulsate. Its oscillations give us important information about the internal structure of white dwarfs and their previous evolution. Metaphorically speaking, this means studying the life of a star by analyzing what is left after its death. But there is a problem: white dwarfs pulsate very fast. Interruptions caused by the day and night cycle proved a major hindrance to data analysis. In other words, uninterrupted observations were needed. These can be made from an orbit around the Sun, as Kepler did, but a different system was developed, much cheaper one at that. Various groups of scientists agreed to coordinate their observations. A campaign was launched that initially included five telescopes. Today, there are as many as 14 telescopes that are located at different longitudes. When day starts in America, it is nighttime somewhere else, so it is still possible to get down to work.

Let us look even deeper into space. Is there life out there?

I wish I knew. We know for a fact that there was water on the Moon and on Mars; there is probably still some left. And water is, after all, an essential precondition for life as we know it. But water alone is not enough. On the other hand, there may be creatures out there that we have never thought could exist. Aside from that, if life emerged on Earth, it might have emerged elsewhere, too. But there is a long way from knowing that something is possible, to knowing that something actually happened. In any event, we have not found any forms of life in the solar system yet. As for what is happening outside the solar system, we don't even know how to look for them.

There was a program called SETI. It searched for signals coming from the space.

As far as I know, it never found anything.

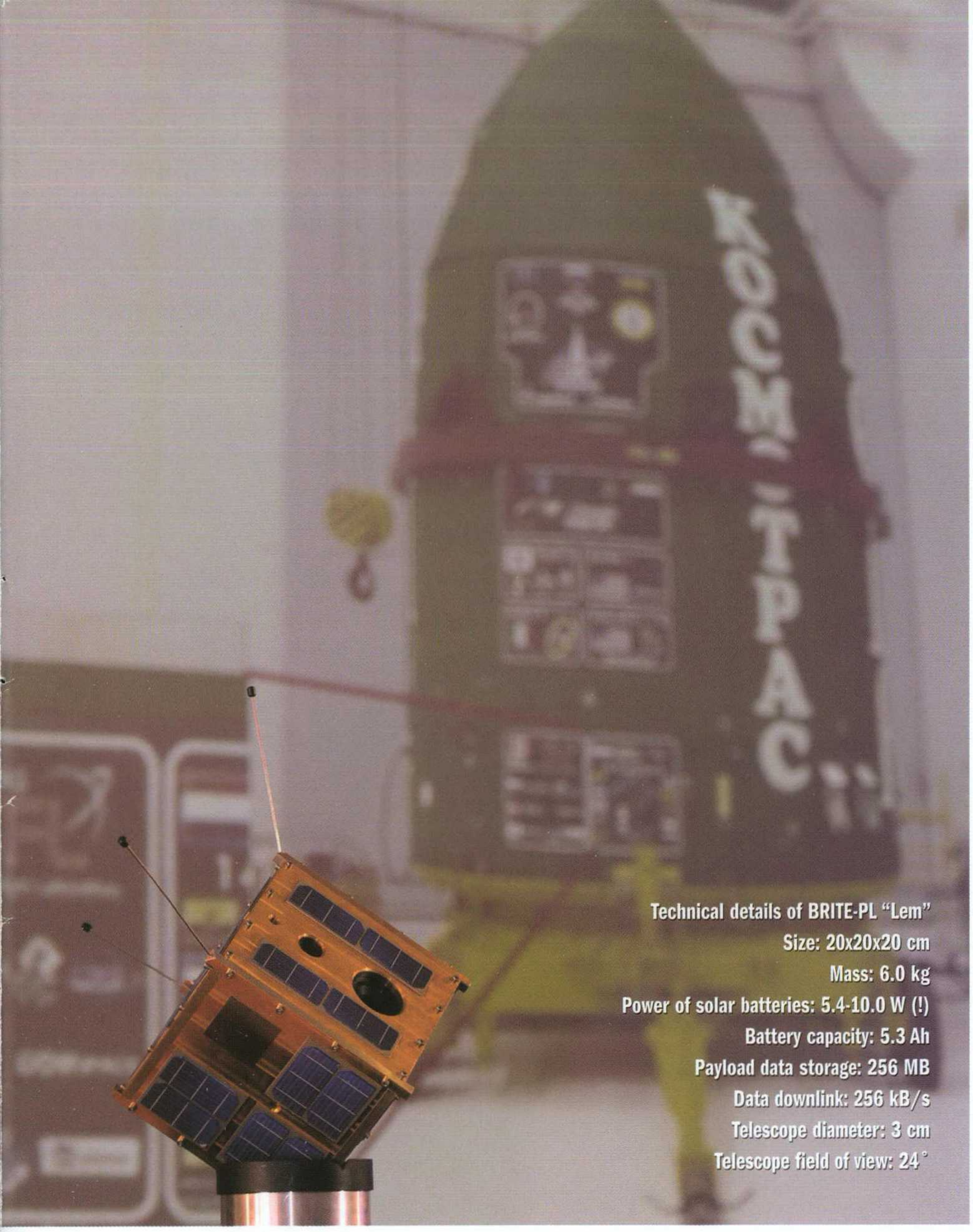
So is it worth continuing?

Of course. It may never find life, but it does collect extremely valuable astrophysical data, specifically radio astronomical observations from various sources. After all, objects shine in the radio spectrum, too! At this point, we are observing outer space at all electromagnetic wavelengths. Each gives us a chunk of information complementary to another chunk of information from another range of wavelengths. The more ranges we have, the more we can find out.

But this is also where one fundamental problem appears: How do we know that a given signal is natural, not artificial? I don't know if anyone knows the answer to this question. We must bear in mind that we keep looking through the only prism available to us, the prism of human beings. We could find life that behaves the way we think it should behave. But what if it turns out to be completely different?

So is there any point in trying to send out information about our civilization into space?

It's hard to say. Those letters sent out on probes travelling outside the solar system have not reached any destination yet. Voyager 1 has gone the farthest. It has just left the solar magnetic field, not the solar system, as people often say. But this is still not far enough: light needs several hours to get from there to Earth. To put this into perspective, it takes four years for light to reach the nearest star. So from the perspective of sending out messages, Voyager has not yet gotten anywhere. The radio signals we have sent out to other potential civilizations will need a few



years to reach any stars. If there is anyone out there willing to listen to them and respond, it will be years before this happens. In space, distances are huge. Radio waves propagate at the speed of light, "merely" 300,000 km/s. This means that it takes them decades to reach other stars, even thousands of years for the most distant stars in the Milky Way. Light takes 170,000 years to reach the nearest galaxy, so it is too slow given the size of the universe. But we know of nothing that travels faster than light.

Will the era of human spaceflight ever come back?

But it has not ended, people keep flying in space all the time! As we speak, there are six people out there, above our heads, on the International Space Station (ISS). Crews rotate: three people fly there for six months and come back. There are always three people in orbit who have already been there and three newcomers.

What about further expeditions?

That's a political question rather than a scientific one. Technically, this has been possible for many years. We went to the Moon over 40 years ago. We could try to repeat that, we could try to go to Mars. But all those ideas are very costly. The question is, who should pay for them and why? For the time being, manned spaceflights are state-funded operations. There are no private spaceflights. And if taxpayers should spend their money on something, it is necessary to convince them it is worth it. Measured by today's prices, the Apollo Project cost over $100 billion. Back then, America needed to show the whole world that it was better than Russia. So there was a reason, an ideological one at that, and President Kennedy made himself clear about that. When the United States won the race, a decision was made to reduce spending on space exploration. Today, only Earth-orbit flights are made, because they are much cheaper.

In my opinion, no decision to make journeys farther afield will be made until there is some significant political or economic justification. Or unless someone manages to build rockets that are 10 times cheaper, in which case spaceflights will become comparable to other major projects price-wise. Right now, flying even to the Moon means huge costs. NASA has estimated the cost of flying to Mars at $500 billion. Knowing NASA, the real budget would end up being at least twice that.

What will be the future of space exploration and astronautics?

Those are two different questions. The field of astronautics encompasses everything we do in space. Human spaceflights are the most exciting aspect, best visible in the media. But let's face it, it is also the least important aspect. At present, the Americans don't fly into space in their own spaceships. They don't have any. They are developing a new manned spacecraft, which will be introduced into service in a few years. This is already the third idle period in US manned spaceflight. A similar one followed the completion of Project Apollo and lasted six years. The one after the completion of Project Gemini was much shorter. The Russians generally don't have such breaks. They're currently the only nation in the world that has an active human spaceflight program. The Chinese are just starting and learning. They're doing well, but they're in no hurry. China's next human spaceflight is scheduled to take place in three years.

Most of astronautics, though, involves various unmanned flights. We have scientific satellites, for example astronomical observatories in orbits around the Earth. There are over 20 space telescopes of different classes circling the Earth. Hordes of satellites are out there just to watch our planet, partly for peaceful reasons such as remote *sensing, the detection of resources, harvest forecasts, and weather prediction – Google's maps are created by satellites, too. And partly for military reasons: there are satellites commonly referred to as spy satellites. These are reconnaissance satellites used for all sorts of reconnaissance operations. Many satellites orbit the Earth to make money, for example communications satellites, owned by privately-held companies. These satellites give us global communications. GPS satellites, which are often used, were created for military reasons, but they are commonly used for civilian purposes. They were designed chiefly to guide ballistic missiles, more specifically to determine the position of submarines carrying nuclear warheads.*

The whole spy-satellite sector is extremely useful. Both sides use them to keep an eye on each other and monitor each other's moves. They are not afraid of each other, because they know exactly what the situation is on the other side. Spy satellites stabilize the military and political situation in the world, so they will be used for as long as there is political life on this planet. Commercial satellites will exist, too, as long as there is money to be made. And scientific satellites will continue to fly as long as people are interested in scientific pursuits. As a matter of fact, it's not so obvious that interest in science is innate to human beings. As a species, human beings have a curious nature, but will things always be like that? I hope so.

How would you describe Poland's involvement in space exploration?

It is rather modest yet significant. And it did not start today. For 30 years, the PAS Space Research Center has been building devices that are installed on various satellites from Russia, America, and Europe. For example, such devices can be found onboard the European spacecraft "Rosetta," which will reach Comet Churyumov-Gerasimenko next year. We have built around 70 various scientific instruments in Poland. Most of them have worked well, so our involvement is important and long-term. Launching a satellite built and assembled in Poland, all the engineering aspects of BRITE, is the next step. Most parts were produced in Canada and the satellite was licensed by the Canadian company that constructed it. But it was assembled and tested in Poland.

Heweliusz, the next Polish satellite, will have a greater share of parts produced in Poland. Simply put, we are still learning. Building a single instrument is one thing. Integrating, testing and controlling the operations of a satellite based on many systems that should work together is quite another. BRITE is a small satellite, but you have to start from something. If we learn such things, we will be able to consider larger satellite projects, not necessarily scientific but also commercial ones, for example in the field of remote sensing.

How did you become an astronomer? Were you tempted by the science fiction writer Stanisław Lem?

No, I liked reading Lem's novels, but everything started from Prof. Włodzimierz Zonn's books addressed to children and teenagers and illustrated by Bohdan Butenko. I took an interest in astronomy, because they were simply beautiful and extremely absorbing. All those drawings featuring astronomers in pointed hats with stars and moons!

BRITE might be a great opportunity to make children aware of astronomy.

I think it's worth considering this idea. Such things are important. They inspire people to take an interest in science, especially in the exact sciences. No modern society can exist without engineers and technicians. But that requires some knowledge of physics and mathematics. Schools are not doing a very good job educating kids in these fields. Most of them think mathematics is scary. But it is the simplest thing in the world. You don't have to learn it, all you need to do is understand it!

Interview by **Anna Zawadzka**
Photos **Jakub Ostałowski**

Prof. Paweł Moskalik (1961) is an astronomer and expert on astronautics, asteroseismology, and the evolution of stars. He received his PhD in astrophysics in 1987, his DSc (habilitation) degree in 1997, and the title of professor in 2011. He works at the Nicolaus Copernicus Astronomical Center in Warsaw, affiliated with the Polish Academy of Sciences. He is one of the Polish participants of the Whole Earth Telescope and a popularizer of science.