Sprites, Elves and Fairies:
Elusive Phenomena High above the Flash of Lightning in a Thunderstorm

Open University physicist Prof. Yoav Yair and his colleagues are in the forefront of scientific discoveries about the nature and effect of transient luminous events in the atmosphere.

Everyone is familiar with the awesome power of flashes of lightning that occur during a thunderstorm. But few are aware that high above the thunderstorm occur a whole array of other lightning-induced atmospheric emissions, also powerful but almost invisible to the naked eye. These transient luminous events, a collective name for emissions such as the whimsically-named sprites, elves, fairies, gnomes, jets and halos, are now the subject of study by Prof. Yoav Yair, Senior Lecturer, Department of Natural Sciences and Director of Shoham, the Center for Technology in Distance Education at the Open University, together with his colleagues and students. Their exciting recent discoveries have placed them in the forefront of research into the nature of these phenomena.

"Sprites were first discovered in 1989," said Prof. Yair, "and since then have attracted a great deal of scientific attention. These mysterious creatures exist high above the lightening, all hidden, and affect the chemistry of the upper atmosphere. They are new to us, complex, and frankly, quite beautiful."

Lightning occurs between the thunderstorm and the ground and is so powerful that as we now know, it can even have an effect on health of people who are sensitive to changes in electric fields. However, explained Prof. Yair, "some types of lightening have an impact not only on the lower atmosphere, but also in the upper atmosphere, some 40-100 km above the earth's surface. This is a region far detached from

Research

us earth-bound humans and it is there that transient luminous events such as sprites, gnomes, pixies and fairies appear immediately after lightening. Together, these phenomena suggest that thunderstorms exert a much greater influence on the middle and upper atmospheres than was previously suspected.

"Transient luminous events are caused by gas molecules that are 'excited'. When they go back to their normal state, they emit light. Although they are huge, about 50 km in size, and very bright, they occur so quickly - only l millisecond (one-thousandth of a second) to 50-60 milliseconds - that they are beyond human vision. They occur all the time above us without us being aware of them, but seen through sensitive cameras, they are magnificent. In recent years, many sizes and shapes have been discovered. Some are halo shaped, others long, like candles. They are mostly red, but also blue and purple."

Israeli scientists are interested in the study of transient luminous events for a number of reasons. For one thing, Israel is one of the very few areas which experience thunderstorms in winter and thus the country offers a unique viewpoint to study these phenomena. Winter thunderstorms tend to be compact and small, unlike the kind of large, active summer thunderstorms which occur in tropical regions like Brazil. Storms here are caused by a combination of warm sea and cold air mass above the water, something shared by Japan, whose scientists were the first to discover sprites in winter. Israeli scientists were the first to discover them in the Mediterranean region.

A second reason that Israelis are in the forefront of discovery in the field of imaging of lightening-induced atmospheric emissions is that this was one of the scientific research projects begun on the ill-fated space shuttle Columbia and which has been continued as its heritage. Prof. Yair was himself a mission scientist at NASA on this project and coordinator of the Israeli research program on the NASA shuttle. "When we proposed to the scientists at NASA that we undertake this secondary project on the Columbia shuttle to study sprites in outer space, they said that sprites are unimportant; they are like rainbows, beautiful but insignificant. But now, we realize that they influence the chemistry of the atmosphere and can have an impact on the ozone level and its structure. This is not a negligible phenomenon."

The most recent exciting discoveries made by Prof. Yair and his team involve spectral measurement.

"We are looking at the intensity of light, which will allow us to calculate the energy of the events and give us insight into the physics of the phenomena," he said. "Local scientists have been active in creating three-dimensional structures of those events, by simultaneous measurement from different places in Israel - Tel Aviv, Jerusalem and Mitzpe Ramon. These stereoscopic images are combined in a way that provides a three-dimensional view.

"Recently, I was analyzing an image of a number of emissions and my wife, who was looking at them too, happened to notice that in three-dimensional terms, they seemed to form a circle. When I looked at images taken from other places, the same pattern occurred. At a scientific meeting in San Diego, my colleagues remarked, 'Now that you mention it, we do see this pattern.' This is new and exciting. I hope that with stereoscopic measurements, we will be able to determine the dimensions of the circles and how the elements are arranged, as well as the separation between them.

According to speculation, sprites or jets or both are an integral part of every thunderstorm system of moderate size or larger and may be an essential part of the earth's global electrical circuit. The work that Prof. Yair's team is conducting may help to confirm this: "Every new image poses new questions and drives us to find new answers. We have a young and enthusiastic group of students who are dedicated and eager, and who are helping to make discoveries such as the physical measurements of sprites, the amount of light at certain wavelengths emitted from sprites and the relationship between the strength of the lightning and the strength of the sprite."

Israel's achievements in this field have been so prominently recognized that Japanese scientists, who are now planning a satellite to measure the global distribution of sprites, have asked Prof. Yair's team to verify their studies from the ground. In short, "In spite of our limited resources, Israeli research on transient luminous events is in a very good place."