Radiation Study

ODU Has Role

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While Viking scientists are signaling the lander on Mars to sift through the red Martian soil for clues to the origin of our solar system and even of life itself, other scientists are setting their sights thousands and millions of light years beyond, including a region of space that some call the edge of our visible universe.

Astronomy is now breaking its bonds to this world by orbiting satellite telescopes thousands of miles above the earth, and several Old Dominion University physicists are playing a role in this effort to focus on vistas never before seen by man.

The latest of these telescopes scheduled to go into space is the International Ultraviolet Explorer or IUE. The National Aeronautics and Space Administration, the Space Council of the United Kingdom, and the European Space Research Organization have joined hands to launch the 14-foot-long satellite in 1978 in order to take a special look at ultraviolet radiation, that invisible part of the spectrum just beyond the wavelengths our eyes perceive as the color violet.

Many questions remain unanswered for the project designers. And the ODU project is studying one of them: what effect might radiation in space have on the satellite's optical and electronic systems.

The ODU physics department has received a $150,000 grant from NASA to try to arrive at some answers. This is one of the largest grants the physics department has ever received for a research project, and it is expected to be extended until at least 1979.

Just as earthly elements can affect telescopes housed on the ground, cosmic rays from outer space, solar flares, and speeding atomic particles caught in the earth's magnetic field can play havoc with a space telescope's delicate mechanisms. Each will be a target for study by the ODU scientists.

Heading up ODU's radiation study team as its principal investigator is Dr. Jacob Becher, assistant professor in physics. Becher came to ODU eight years ago as an expert in spectroscopy and optics, a fact he disclosed with some amusement since he admitted that he was color-blind to certain shades.

According to Becher, the ultraviolent wavelengths that will be sought out by the IUE have an important place in the history of astronomy. "Astronomers have longed to study ultraviolet rays since the turn of the century. Many atmospheric phenomena such as air glows and auroras are influenced by them, and scientists were interested quite early in observing this. But they had to be patient and wait for rocket technology to be developed first. Rocketry finally gave them the capability of going beyond the earth's atmosphere to see those ux-rays. Only about 5 per cent actually get through our atmosphere so they're impossible to study here on the ground."

The IUE is expected to change all that as it focuses its telescopic eyes on galaxies, nebulae, and interstellar dust—building on a picture of the universe seen by earlier space telescopes.

To find the reasons scientists are so anxious to carry on such experimentation, one must go back more than 40 years.

Astronomy's real push to study different wavelengths of electromagnetic radiation in space came about by accident. In 1931, K. G. Jansky of the Bell Telephone Laboratories was working with antennas for transoceanic radio communication, but he kept running into interference. The static, it was discovered, was not coming from earth, but from outer space. So it was by chance that radio astronomy came into being.

Until then, astronomers had been studying mainly what they could see with their eyes, the visible light of the universe. Photographs recorded that light. It was also analyzed by spectroscopes, instruments that break the light down into its component wavelengths—much like a prism breaks white light into a rainbow of colors. Such information as the composition and temperature of stars can be discerned from those spectra.

But the light we see with our eyes comprises only a small part of the electromagnetic spectrum, which ranges from radio waves miles in length to visible light with waves about 20-thousand-billionths of an inch long, to even smaller X-rays and gamma rays. The universe is virtually teeming with all this varied radiation.

As noted inventor Buckminster Fuller once said, "Humans have learned that what they can touch, smell, see, and hear is less than one-millionth of reality. Ninety-nine per cent of all that is going to affect our tomorrows is being developed by humans using instruments and working in ranges of reality that are nonhumanly sensible."

So Jansky's accident opened a vast new window for observation. With great excitement astronomers began looking at many different wavelengths emanating from the heavens—radio waves, infrared waves, and X-rays—waves not perceived by our eyes but only through special instruments.

Because of it, astronomers began seeing a universe populated with such intriguing objects as the pulsars, stars that emit sharp radio pulses so regularly that they were initially mistaken for signals from extraterrestrial beings. And then there were the quasars, mysterious objects believed to exist at the very edge of our visible universe billions of light years away. These were phenomena never even imagined by science-fiction writers.

A major portion of the ODU research team's experimentation for the IUE project takes place in a four-room laboratory adjoining Becher's office, a lab filled with oscilloscopes, vacuum pumps, computer terminals, radiation chambers, and spectrographs.

Work under the NASA grant began in February, 1975, and much of it was preliminary investigation. Becher says they have several aims. "We want to see exactly how the radiation out in space will affect the IUE's ability to detect distant stars. We're also interested in measuring how the materials in the satellite are going to deteriorate as they're exposed to more and more radiation. This will tell us how long the telescope can be expected to survive out in space."

The telescope's major obstacle is the Van Allen belts. These are doughnut-shaped zones of highly energetic charged particles that are trapped in the magnetic field high above the earth. The IUE will be placed in an orbit over the Atlantic Ocean at an altitude of about 25,000 miles so that it will always be visible from the observing stations in the United States and Europe. But that same orbit will also place it in a Van Allen belt for several hours each day.

Dr. R. L. Kernell, associate professor in physics at ODU and co-investigator on the project, says they're looking at two key questions in regard to the belt. "Can the satellite take data while in the belt or will the radiation overpower any useful information it can get? And secondly, how long will the telescope need after it comes out of the belt to recover from the temporary effects of the radiation?"

To begin those investigations, the research team has had to simulate the environment of the Van Allen belts—an almost infinite number of electrons hurtling by at energies up to three million electron volts. They've done this both by using a radioactive source right in their lab and by using particle accelerators in Newport News and Maryland. Each method was used to study a particular aspect of the satellite system.

Becher and Kernell are especially concerned with the radiation effects on two pieces of equipment that will be aboard the satellite—an ultraviolet-to-visible light converter and a fine-error sensor.

Once the ultraviolet rays of a target star or galaxy are sent through the spectrographs of the space telescope and broken down into a spectrum, the information must be sent back to earth to be analyzed. This is usually done through use of a television camera, but since the vidicon tube they are using is not sensitive to ultraviolet light, the uv-rays must first be converted to visible light in order to be detected by the camera. That's the job of the ultraviolet-to-visible light converter.

But there's one problem. If radiation such as an electron enters the converter instead of ultraviolet ray, the converter won't be able to tell the difference. It will still "think" its seeing a star, keep releasing visible light, and so a false image could be built up on the television camera.

Dr. Chester Reft, assistant research professor with the ODU project, has done most of the in-lab experimentation on this problem using strontium-90 as his source of radiation since it gives off electrons. "At the start of the experiment, we really weren't sure of what to expect," says Reft. "Depending on the dosage of radiation hitting the converter, we did get a fairly large signal coming out and being registered. We're now in the process of designing more elaborate experiments to determine the exact mechanisms causing that signal."

The research team isn't without its theories on the subject. The converter can be considered an enclosed chain reaction. The uv-ray enters and strikes a material that emits an electron; the electron in turn hits a phosphor which then glows and releases a particle (or photon) of visible light. The light is then recorded on the TV camera. The team believes that an electron entering the converter can activate it just like a uv-ray. They also believe that an electron coming in from the outside can directly activate the converter's phosphor.

Reft noted, "We're also looking at a third possible mechanism known as Cerenkov radiation. Light slows down when it enters a medium like glass after traveling through the air or a vacunm. So an electron, if it's energetic enough, could enter the glass and actually surpass the speed of light. This creates new electromagnetic radiation. In the converter, this might also set up a false signal."

While the relatively weak radiation from the strontium-90 was adequate to study a sensitive device such as the converter, the research team needed a much stronger source of radiation for study of the fine error sensor. The sensor is part of the guidance system that will lock onto a star and keep the telescope from straying off its position while in use. The sensor will be able to pick up stars as dim as the 13th magnitude. In comparison, our eyes can see only about sixth magnitude stars (the higher the magnitude, the dimmer the star).

It was important for the ODU team to see months of radiation damage on the sensor's parts without waiting those months. In order to do that, they went to the particle accelerator at the Space Radiation Effects Laboratory in Newport News and bombarded various glasses, components of the sensor's focusing system, with billions of electrons per square centimeter. This simulated months out in space in just about an hour.

"We saw those glasses become discolored due to the radiation," says Kernell. "This obviously will decrease the efficiency of the sensor since the radiation effects will cut down on the light it will be able to see."

Currently, the data is being studied to determine what type of glass is most resistant to the radiation and can recover the quickest from the damage.

So far, the major recommendation the team has made regards shielding. "The IUE Project is pretty well set," says Becher. "So our main mission is to make NASA aware of the problems that could arise. We have recommended increased shielding for the converter and fine error sensor to cut down the radiation that can enter, but these are minor changes. We have every indication that the IUE will function well in its environment."

But the team's data won't be lying idle. They actually have two missions to perform. Becher says, "Our data is also being applied to the Large Space Telescope Project. This is a larger telescope than the IUE that's expected to be put up by the space shuttle in the early 1980s. Since the telescope is still on the drawing board at this time, our data will aid them in actually designing it."

The aim of the Large Space Telescope or LST is to "see" the edge of the universe in order to better determine the universe's age and origin. To Becher, exactly how large the LST will be depends on Congress. "Right now the LST is getting shuffled back and forth in Washington. The edge of the universe seems less important these days to legislators when compared to our more immediate social problems. But many astronomers are saying it would be the most imporatant astronomical experiment in our century."