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NASA's SOFIA: The Airborne Telescope Prepares to Take Flight

SETI THURSDAY

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NASA'S SOFIA, the Stratospheric Observatory for Infrared Astronomy, is the world's largest portable telescope specializing in infrared astronomy (IR). IR can be thought of as the "light" emitted by objects not hot enough to shine in visible light. We humans emit IR - it is the heat from our bodies. Astronomically speaking, IR observing allows scientists to study the dust between stars, the formation of stars and new solar systems, the chemistry of the universe, and the deep universe where the most distant galaxies are seen in infrared light. When research missions begin, SOFIA, a modified Boeing 747SP will carry a 2.5-meter telescope up to the stratosphere to observe a universe invisible from ground-based telescopes.

SOFIA will host a complement of scientists, computer engineers, graduate students, and educators on nightlong research missions. When the observatory lands at NASA Ames Research Center's Moffett Federal Airfield, this tired group will exit the aircraft with new data and images of the infrared universe. Research missions begin in late 2004.

Often, I present talks and workshops on infrared astronomy and SOFIA for educators and the public, and I frequently hear the same, amazed questions from the audience.

Why put a telescope in an airplane? Why are we mounting a telescope in an airplane--a moving platform--instead of mounting it securely to the ground atop some remote, dark mountain, or sending it to space? The reasons are straightforward: the water in Earth's atmosphere absorbs almost all of the infrared energy from objects in the universe. All that IR energy can travel millions of light years through space to be stopped by the last 5 miles of Earth's atmosphere. A few infrared windows--parts of the electromagnetic spectrum--are available to the ground, and are well observed by projects like 2 MASS, the 2 Micron All Sky Survey. The fact that 99% of the water is concentrated in the lower atmosphere, up to about 40,000 feet elevation makes it possible to create an airborne observatory for IR astronomy. By flying above the water in the stratosphere (humidity less than 1%), a whole new infrared universe opens up to view.

Why not just put the telescope in space? Scientifically, SOFIA can do much of the IR astronomy that is also accessible from space, but with the advantage of being a ground-based observatory. SOFIA is akin to a space mission that lands every morning. Science instruments (cameras, spectrometers, photometers, etc.) can be mounted to the telescope while the aircraft is in the hangar and can be changed out, repaired, or replaced with newer technology on the ground. Because

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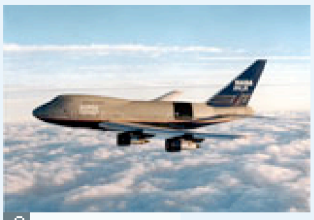

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SOFIA is a 747SP seen here during flight tests. Credit: NASA &Universities Space Research Association

of this flexibility, the observatory life span is projected at 20 years. Cryogenics can be replenished for each flight. SOFIA's sister mission, SIRTF (Space Infrared Telescope Facility) will be a space-based infrared telescope and scientists anticipate that SIRTF will work for up to 5 years before its cooling system runs out of helium and the telescope warms up. These two NASA missions are truly complementary.

How can you point a telescope accurately when it is on board a bumpy, moving aircraft? Basically, the SOFIA telescope--all 22,000 kg or 48,000 lbs.--is isolated from the 747SP. The telescope is permanently mounted into the aircraft on a large, hydraulic bearing (about 1.6 meters in diameter) in a pressure bulkhead between the telescope cavity and the cabin. The telescope floats on this bearing. Once the telescope begins tracking a star, a combination of the bearing, shock absorbers, laser gyroscopes, and a feedback system keep it pointed accurately. The aircraft just rocks and rolls around the telescope, which is locked onto the sky. NASA's Kuiper Airborne Observatory (KAO), now retired, had a similar system for a smaller (36") telescope that worked well for more than two decades.

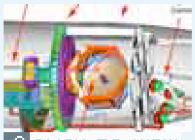
Is there something special about IR telescopes? Yes, there is. To collect the best quality data and images, IR telescopes and detectors are operated at very low temperatures. When observing, the SOFIA telescope will be at the ambient temperature outside of the aircraft, about -35 C (240K to use a temperature scale common in astronomy). The instruments attached to the telescope to collect the IR light will be cryogenically cooled close to absolute 0 (-273 C, or 0K) so that the "background" IR observed with objects will be as low as possible. SOFIA's sister mission, SIRTF, is a space-based infrared telescope, and the entire SIRTF telescope will be chilled to a low temperature with a huge liquid helium refrigerator surrounding the telescope.

Do people have to wear space suits on board SOFIA? No, the cabin of the aircraft is pressurized for human comfort just like commercial airlines. In fact, SOFIA will be certified by the FAA, and will be able to fly into commercial airports worldwide that are able to host 747's. As a team member for USRA, United Airlines will provide the flight crew and maintain the aircraft.

Who is building SOFIA? SOFIA will be a world-class observatory for research astronomy, and is a joint project of NASA and the German Aerospace Center, DLR. NASA is funding the modification of the 747SP into an observatory, and the DLR is building the telescope. Universities Space Research Association (USRA) is the prime contractor for NASA's work. USRA and its subcontractors like United Airlines will operate SOFIA for NASA and DLR. The scientific leadership for the observatory is from the University of California, and instruments for the observatory are being designed and constructed at major universities and NASA centers across the nation as well as in Germany. The actual modification is being done by L-3 Communications in Waco at the same airport that President George W. Bush uses when he visits his ranch in Texas.

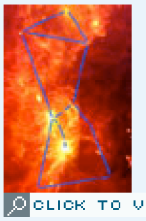
Who can fly on SOFIA? SOFIA will be a working research observatory. Researchers who have been awarded observing time will fly, often with their graduate students and postdoctoral associates. The observatory will have staff: telescope operator, mission chief, and computer systems people who are responsible for operating the telescope system with the science team. Of course, there is a pilot, co-pilot and flight engineer to fly the plane. In addition, like the KAO, SOFIA will host educators on research missions as a part of the observatory's Education and Public Outreach (EPO) program. The EPO program is being conducted by the Astronomical Society of the Pacific and the SETI Institute, working closely with USRA for NASA.

How can I learn more about SOFIA? Do you want to stay tuned to SOFIA? Sign up at the SOFIA web site. If you are interested in a career related to SOFIA, in scientific opportunities with the observatory, or in more information for educators and the public, please visit the SOFIA web site and register your interest as a scientist or as an educator to receive electronic newsletters about the progress of the observatory.



A cutaway view of SOFIA.

Orion in visible light.
CREDIT: Akira Fujii



Orion in Infrared. Credit: NASA

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