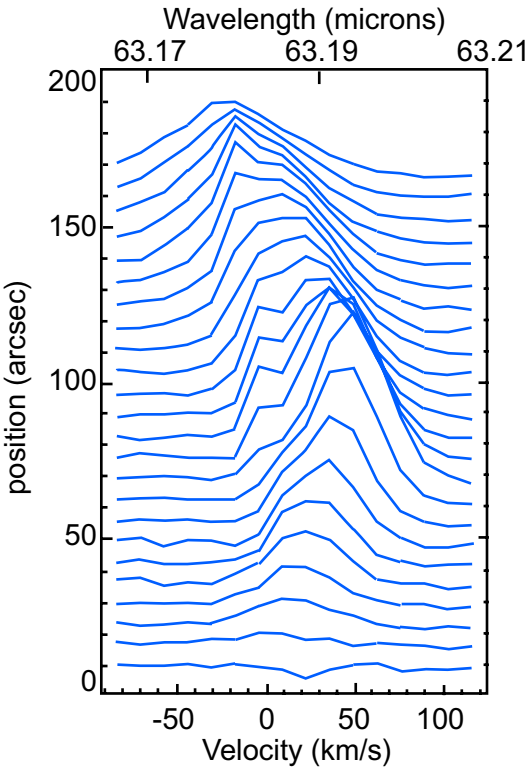
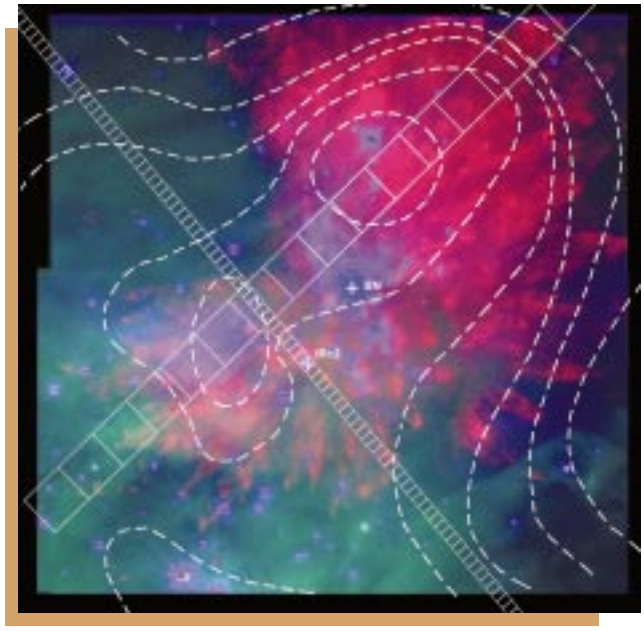
An Airborne Infra-Red Echelle Spectrometer for SOFIA

Ames Research Center

SOFIA, the Stratospheric Observatory for Infrared Astronomy, will enable astronomical observations with unprecedented angular resolution at infrared wavelengths obscured from the ground. To help open this new chapter in the exploration of the infrared universe, we are building AIRES, an Airborne Infra-Red Echelle Spectrometer. AIRES will be commissioned when the flight program begins in 2003, and will be operated as a general purpose facility instrument by USRA, NASA's prime contractor for SOFIA. The two figures here illustrate some of the observational capabilities of AIRES.



Synthetic spectra of the 63 μm line as could be measured with AIRES. Depending on detector type, AIRES will measure 12, 24, or 128 spectra simultaneously from different locations (pixels) along the slit. The K-mirror (image rotator) will orient the slit at any position angle on the sky.



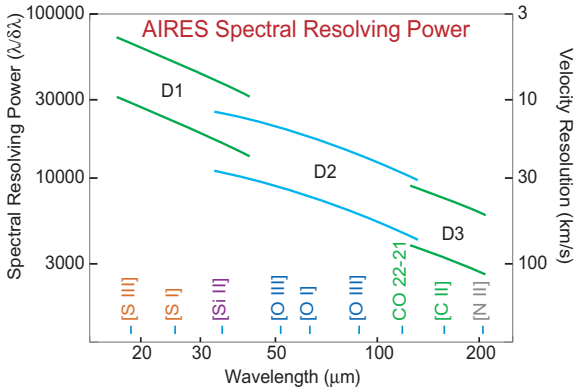
A NICMOS image of Orion shows molecular hydrogen emission (2.1 μm) in red, Pα(1.9 μm) in green, and 2 μm continuum in blue. Superimposed are neutral oxygen [O I] 63 μm contours measured from the KAO. Outflows from embedded massive stars produce shocks creating this H_2 and at least some of the[O I] emission. The [S I] 25 μm line will trace the shocks unambiguously. Correlating the morphology of these shock diagnostics will establish the outflow parameters and help identify their sources. AIRES slits for [O I] 63 μm (7") and [S I] 25 μm (3") are shown.

AIRES Science

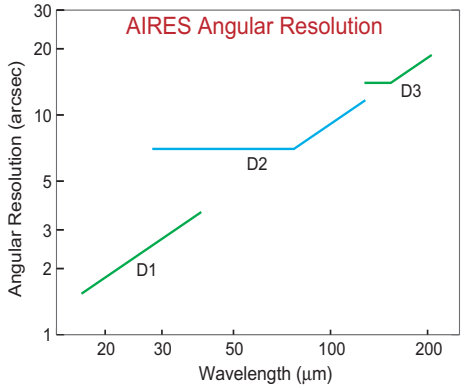
AIRES will be ideal for spectral imaging of gas-phase phenomena in the interstellar medium (ISM). Far-infrared line observations probe the density, pressure, luminosity, excitation, mass distribution, chemical composition, heating and cooling rates, and kinematics in the various components of the ISM. The lines offer invaluable and often unique diagnostics of conditions in such diverse places as star forming regions, circumstellar shells, supernova remnants, the Galactic Center, starburst galaxies, and the nuclei of active galaxies. AIRES will provide astronomers with new insights into these and other environments in the ISM. It will also be useful for studies of solar system phenomena, such as planetary atmospheres and comets, and a variety of other astronomical problems.

AIRES Attributes

AIRES is a long-slit spectrograph with a slit-viewing infrared camera. The design provides spectroscopic wavelength coverage from 17 to 210 μm using three detector arrays: D1, a 128x128 pixel Si:Sb array; D2, a 16x24 Ge:Sb array; and D3, an 8x12 stressed Ge:Ga array. The slit length is about 2.5', and the slit width can be varied from 2'' to 35''. The three figures show the expected performance of AIRES with these arrays as a function of wavelength.



AIRES' large echelle grating provides good efficiency in both high and moderate resolution modes, which are depicted here. Wavelengths of a few astrophysically important lines are indicated. The free spectral range for a given wavelength setting is roughly 250 km/s in high resolution mode. Wavelength and mode changes will take about a minute.



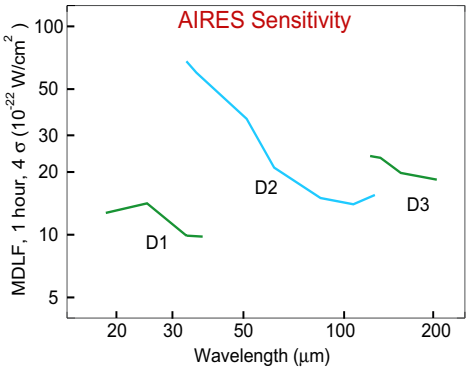
The diffraction limit of SOFIA is about 9'' x (λ/100 μm). AIRES' detectors and optical system achieve the diffraction limit over much of the planned wavelength range.

Only D2 is planned for first light.

First light configuration

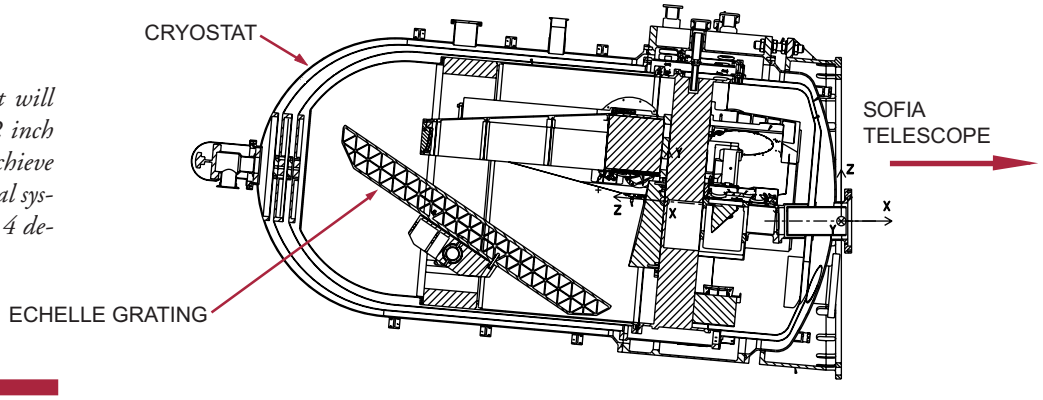
Design configuration

The predicted minimum detectable line flux (MDLF) for an unresolved (narrow) line is shown for the high resolution mode of AIRES. The MDLF for the moderate resolution mode is about 40% higher, depending on the line width.



AIRES Instrument

A cross section of AIRES is shown as it will mount on the SOFIA telescope. The 42 inch long echelle grating disperses light to achieve good spectral resolution. The entire optical system is housed in a cryostat and cooled to 4 degrees Kelvin with liquid helium.



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For more information, visit: http://www.sofia.usra.edu/observatory/instruments/first_light/tables.html