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Studies of planetary nebulae with SOFIA: Current and future prospects

Ravi Sankrit
SOFIA Science Center/USRA

Abstract. The Stratospheric Observatory for Infrared Astronomy (SOFIA) is introduced, its basic properties are presented, and the relevance of the observatory to Planetary Nebula studies is described.

Keywords. space vehicles, telescopes

1. Introduction

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is a joint project of NASA and the Deutsches Zentrum für Luft- und Raumfahrt (DLR). It consists of a German-built 2.7 m telescope (2.5 m usable diameter) mounted in a Boeing 747-SP aircraft supplied and modified by NASA. SOFIA flies at altitudes up to 45,000 feet, above 99% of the water vapour in the Earth's atmosphere, and provides access to a broad wavelength range, including the mid- and far-infrared.

The US and Germany have 80% and 20% shares in the total observing time. Apart from Guaranteed Time Observations for Science Instrument teams, and a limited amount of Director's Discretionary time, this time will be awarded via proposals calls. The call for the US portion will be open to the international astronomical community.

SOFIA will be a valuable resource for Planetary Nebula (PN) studies. It provides the wavelength coverage, angular resolution and spectral resolution that will allow a range of observations to address key questions about PNe. For instance, high angular-resolution imaging in broad and narrow mid-infrared bands, spectroscopy yielding measurements of important diagnostic lines (e.g. from multiple ionization stages of O, Ne and S), and high resolution spectroscopy of emission lines such as [CII] 158 μm can be used to study the dust and molecular content, elemental abundances and kinematics of PNe. (An example of an abundance study using FORCAST, one of the first generation instruments on SOFIA, is presented by Rubin *et al.*, this volume.) The ability to upgrade and replace the instruments on it would allow SOFIA to address new scientific questions after they arise.

2. SOFIA compared with other telescopes

Several mid- and far-infrared observations of PNe have been made with space-based telescopes such as IRAS, ISO, Spitzer and Herschel, and SOFIA's predecessor the Kuiper Airborne Observatory. In Figure 1, the angular resolutions and the photometric sensitivities of these instruments and of SOFIA are shown plotted against wavelength. The comparison among these will help guide the target selection for SOFIA observations. The angular resolution of SOFIA is slightly worse than that of Herschel, but significantly better than the other instruments. SOFIA is about two orders of magnitude less sensitive than Spitzer at 70 μm and below. It is also less sensitive than Herschel over the latter's entire wavelength range – about an order of magnitude lower at the longer wavelengths.

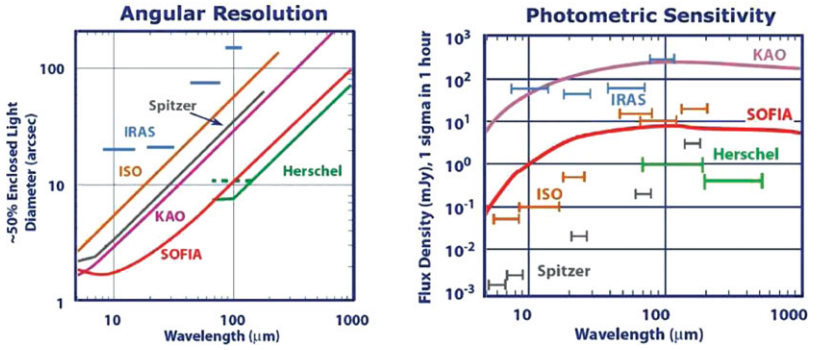

Figure 1. The angular resolutions (*left*) and photometric sensitivities (*right*) of several past and current infra-red observatories are plotted against wavelength. Adapted from SciVis2009.

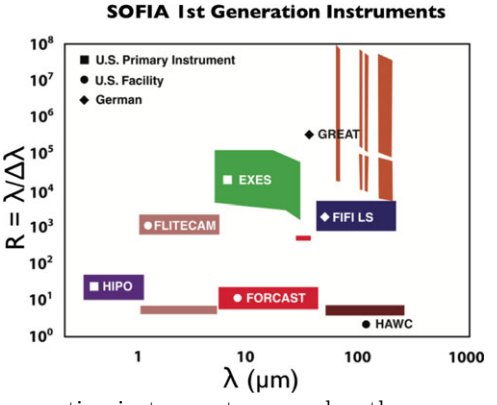

Figure 2. SOFIA first generation instruments – wavelength coverage and spectral resolution (for details see http://www.sofia.usra.edu/Science/instruments/). Adapted from SciVis2009.

But it is worth noting that the difference is only a factor of a few around the wavelength of the important [CII] line at 158 μm. The most useful comparison of sensitivities for indentifying targets is perhaps that between SOFIA and IRAS. A large number of PNe have been observed by IRAS, which, based on their fluxes, would be accessible to SOFIA.

SOFIA is expected to have an operational lifetime of about 20 years. There are seven first generation instruments (Figure 2) all of which have flown or are scheduled to fly by the end of 2012. It is expected that new instruments will become available on a regular basis to keep the instrumentation on SOFIA state-of-the-art. Therefore the results and understanding gained from ongoing studies of PNe could motivate future SOFIA observing programs.

References

SOFIA Project Science Vision Team, 2009, *The Science Vision for the Stratospheric Observatory for Infrared Astronomy* (SciVis2009)

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