ORIGINS Space Telescope

From the first stars to life

National Aeronautics and Space Administration

OST: Breaking the Confusion Limit

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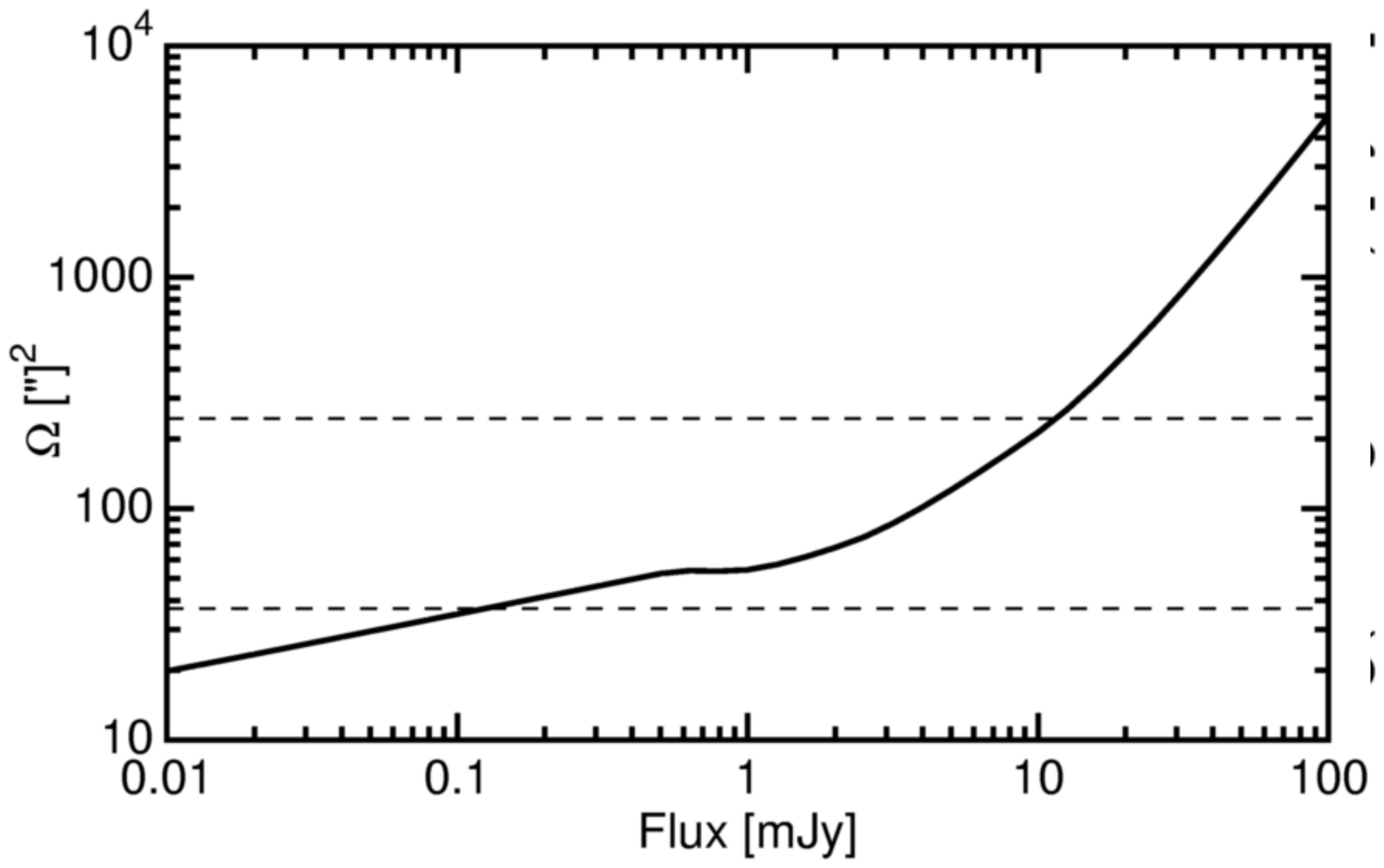
The Origins Space Telescope (OST) is the mission concept for the Far-Infrared Surveyor, one of the four science and technology definition studies of NASA Headquarters for the 2020 Astronomy and Astrophysics Decadal survey. Origins will enable flagship-quality general observing programs led by the astronomical community in the 2030s.

OST will have a background-limited sensitivity for a background 24,000 times lower than the Herschel background caused by thermal emission from Herschel's warm telescope. For continuum observations the confusion limit in a diffraction-limited survey can be reached in very short integration times at longer far-infrared wavelengths. But the confusion limit can be pierced for both the nearest and the farthest objects to be observed by OST. For the outer Solar System the targets' motion across the sky will provide a clear signature in surveys repeated after an interval of days to months. This will provide a size-frequency distribution of TNOs that is not biased toward high albedo objects.

For the distant Universe the first galaxies and the first metals will provide a third dimension of spectral information that can be measured with a long-slit, medium resolution spectrograph. This will allow 3D mapping to measure source densities as a function of redshift. The continuum shape associated with sources at different redshifts can be derived from correlation analyses of these 3D maps.

Fairly large sky areas can be scanned by moving the spacecraft at a constant angular rate perpendicular to the orientation of the long slit of the spectrograph, avoiding the high overhead of step-and-stare surveying with a large space observatory. We welcome you to contact the Science and Technology Definition Team (STDT) with your science needs and ideas by emailing us at ost_info@lists.ipac.caltech.edu



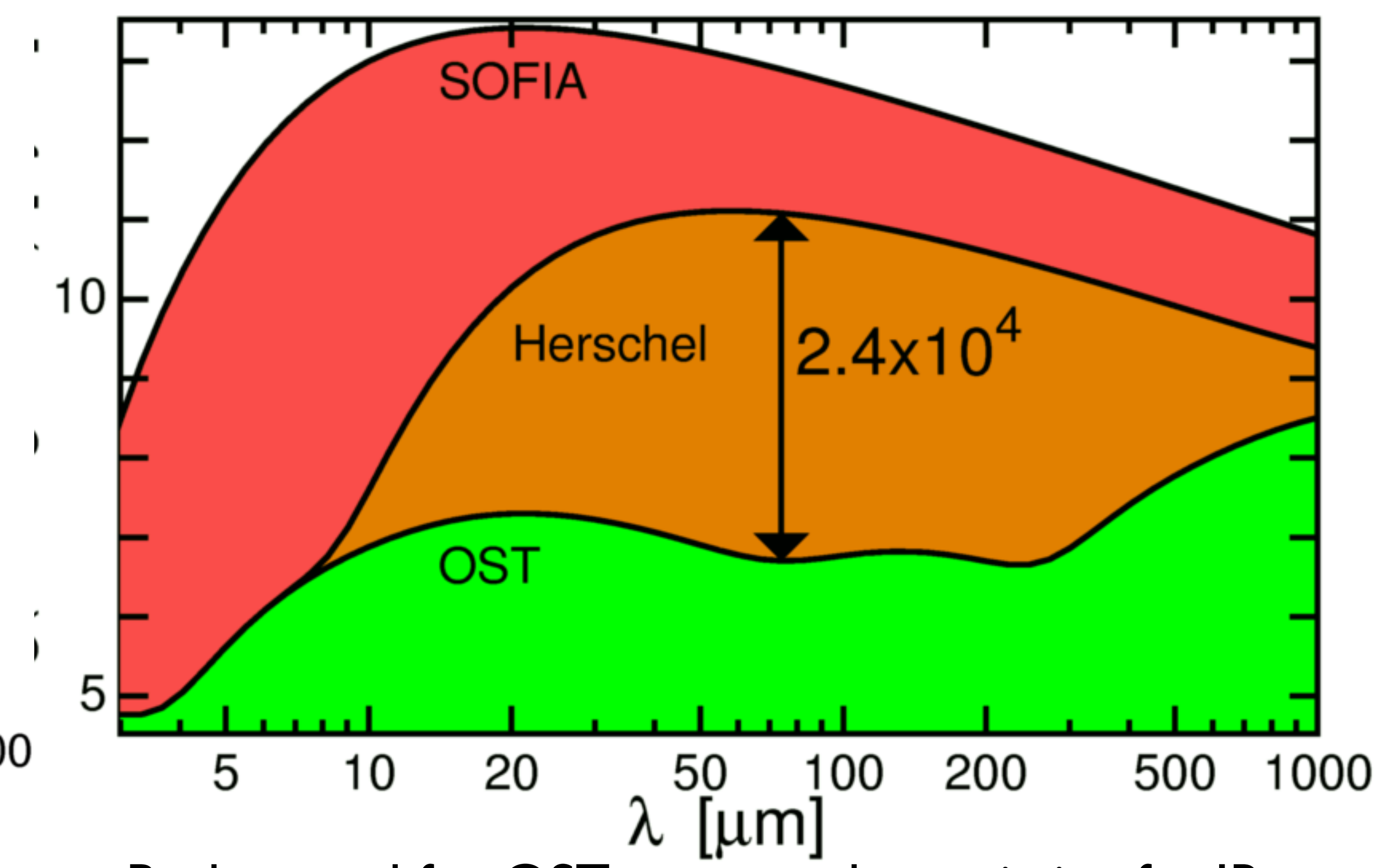
WHAT IS THE CONFUSION LIMIT

The confusion limit is the noise from uncatalogued faint sources that will exist in every beam. The effective beam solid angle depends on the analysis technique, but for source detection using a matched filter it is about $7(\lambda/D)^2$, which is plotted as the horizontal dashed lines for a 3.5 m aperture and a 9 m aperture at 100 μm. The curve is computed using the counts from Magnelli etal. 2013, A&A, 553, 132, and shows the beam area vs the 5σ confusion noise limit.

It is clear that Magnelli etal. were fighting large effects from confusion noise when their published counts stop at 0.56 mJy. An extrapolation with $dN/dS = C/S^{1.25}$ has been used for fainter counts

Whether or not the big break in dN/dS seen by Magnelli is real, then an OST-class telescope will have a much lower confusion limit than Herschel.

Confusion noise is much smaller at wavelengths less than 100 μm.



Background for QST compared to existing far-IR facilities [SOFIA] and past space-missions [Herschel].

FAST SCANNING WITH THE MRSS

The Medium Resolution Survey Spectrometer proposed for QST will have a spectral resolution of 300-500, and about 100 beams in a linear array on the sky. OST is expected to be able to scan at 100 "/sec, and with a long slit length of 6', OST will be able to do a spectral scan map covering 10 square degrees per hour. The integration per beam would be about 20 ms. At this mapping speed the 5σ continuum sensitivity at 100 μm would be 0.5 mJy, and the line sensitivity would be a bit better than 10^{-18} W/m^2.

This line sensitivity in 20 ms is a few times better than the Herschel sensitivity in 1 hour, illustrating the huge advance in capability provided by OST.

A dark [albedo = 0.05] TNO at the continuum limit would have a visual magnitude near 26, making it hard to discover optically, while a 10 Earth mass "Planet X" would be detectable to 8000 AU by its self-luminosity.

The **Origins Space Telescope** is the mission concept for the **Far Infrared Surveyor**, a study in development by NASA in preparation for the *2020 Astronomy and Astrophysics Decadal Survey*.

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Secret OST Word: Confusion