GREAT: German REceiver for Astronomy at Terahertz Frequencies

Principal Investigator Class, Far-Infrared, Multi-Pixel Spectrometer

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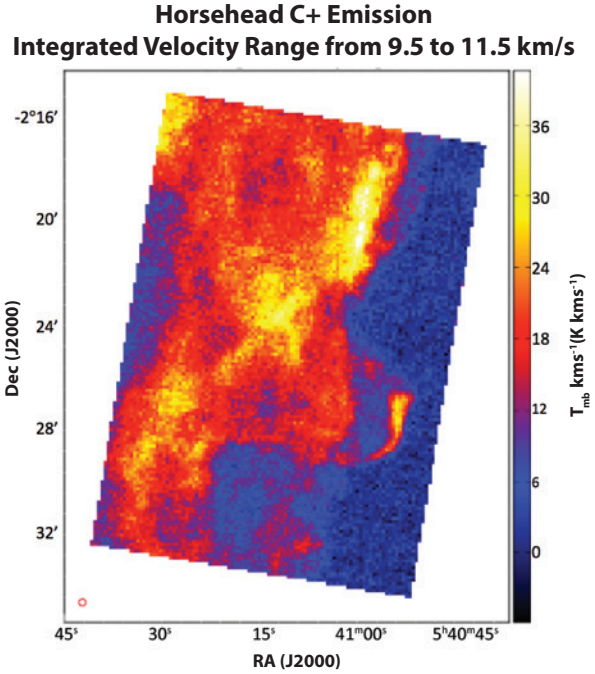
Horsehead Nebula Velocity Resolved Map

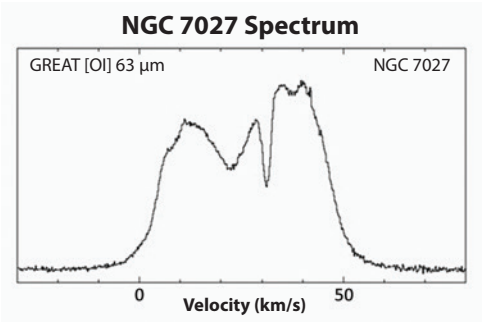
A velocity resolved map of the iconic Horsehead Nebula in the [C II] 158 µm line was obtained by the upGREAT Low Frequency Array (LFA). The [CII] line is one of the strongest cooling lines in the interstellar medium, and here it traces the photodissociation region illuminated by the O9.5V star Sigma Orionis. The integrated intensity image is shown in the figure to the right. The 12'x17' map, encompassing the nebula and the underlying cloud ridge, was obtained in just over 4 hours of observation on a single flight. The angular resolution of the map is 15.1" and the velocity resolution is 0.19 km/s ($R > 10^6$). These remarkably efficient observations were made possible by an increase in the sensitivity of the upGREAT detectors with the use of fourteen independent detectors of the LFA, and the increased mapping speed facilitated by SOFIA's inertially stable platform.

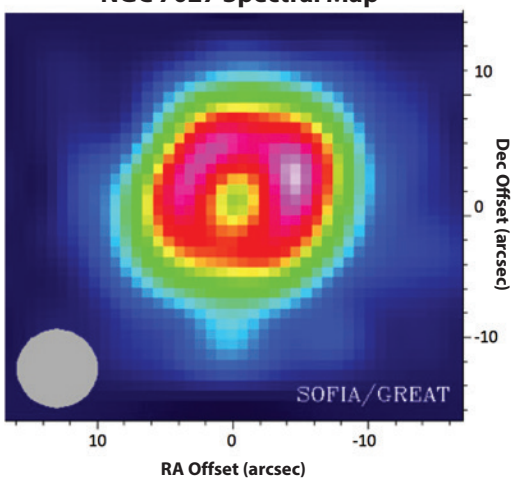


Data publicly available in the SOFIA Science Archive.

Planetary Nebula NGC 7027

Spatial scans made by the GREAT spectrometer's H-channel receiver enabled the production of a spectral map and integrated spectrum for Planetary Nebula NGC 7027 in the [OI] 63 µm line. The effective angular resolution is indicated by the gray circle. The high-resolution spectrum displays the characteristic shape for an expanding, optically thin shell. The complex line structure shows that the expanding nebula has multiple components moving at different velocities. *(GREAT Consortium)*





Specifications

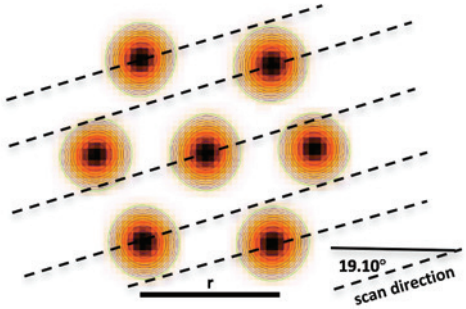
GREAT supports the following Astronomical Observing Templates (AOTs): Single Point, Raster Map, and On the Fly map. Each AOT is run in either of two observing modes: Total Power or Beam Switching.

Observing Modes

Total Power: The telescope moves between a target and a nearby emission-free reference position.

Beam Switching: The secondary mirror chops between the source and a nearby reference position at a rate of ~1–2.5 Hz. The telescope nods between these positions at a slower rate than when chopping.

LFA & HFA Pixel Arrays



A generalized hexagonal pattern of the LFA and HFA. The spacing between pixels, r, is slightly more than two beam widths at ~31.7″ for LFA and 13.8″ for HFA.

Astronomical Observing Templates

Single Point: The telescope observes a single point on the sky to acheive long integration times.

Raster Map: The telescope makes a collection of single point observations to cover a small mapping area.

On The Fly Map: The telescope scans along a row while backends* continuously integrate the incoming signal and periodically write out the data. This process continues to develop a map of the desired size.

*Both 4GREAT and the upGREAT LFA use Fast Fourier Transform backends with a bandwidth of ~2.5 GHz and a channel spacing of 44 kHz. At the [CII] frequency (1.9 THz), this corresponds to a channel spacing of ~0.01 km/s.

upGREAT and 4GREAT

upGREAT and 4GREAT are enhancements to upgrade GREAT. The upGREAT Low Frequency Array (LFA) is a dual polarization, 2x7 pixel array operating at 1.810–2.070 THz, and the upGREAT High Frequency Array (HFA) is a 1x7 pixel array operating at 4744.77749 THz. In On the Fly mode, upGREAT can observe extended regions of the sky efficiently, as shown by the Horsehead Nebula map on the previous page. 4GREAT has four single-pixel channels that observe the same position on the sky simultaneously. Their central frequencies are 0.43, 1.00, 1.37, and 2.54 THz. For Cycle 7, GREAT can be run with the configurations upGREAT LFA with upGREAT HFA or 4GREAT with upGREAT HFA.

Channel Parameters

Channels	Frequency Range [THz]	T_{rec} Double Sideband	FWHM	Astronomical Lines of Interest
upGREAT LFA	1.810 – 2.070 THz	1000 K	15″	[OI], [CII], CO, $OH^2\pi_{1/2}$
upGREAT HFA	4744.77749	1100 K	6″	[OI]
4GREAT	0.490–0.635	120 K	50″	NH_3 , [CI], CO, CH
	0.890–1.100	350 K	25″	CO, CS
	1.200–1.500	800 K	19″	[NII], CO, OD, HCN, SH, H_2D^+
	2.490–2.590	1500 K	12″	$OH^2\pi_{3/2}$, $^{18}OH^2\pi_{3/2}$, HD