Technology Roadmap for the HEterodyne Receiver for Origins (HERO)

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The Origins Space Telescope is one of four large missions studied by NASA, which have been submitted to the 2020 Decadal Survey on Astronomy and Astrophysics.

The Origins Space Telescope is a mid to far-IR satellite with a cooled 5.9m primary mirror. Origins has three bolometer arrays as the baseline instruments and one upgrade instrument, the HEterodyne Receiver for Origins (HERO). HERO [1] is designed to study the trail of water from the ISM to protoplanetary disks. It covers a continuous wavelength range of 486 to 2700 GHz in only 4 bands. Each band has two 9-pixel focal plane arrays, one for each polarization. Hero can carry out dual-polarization and dual-frequency observations. We aim for DSB receiver temperatures around 50 K for the 486 to 756 GHz band, 100K for the 756 - 1188 GHz band, 200K for the 1188 - 1782 GHz band and 300K for the 1782 to 2700 GHz band. HERO has at least 6GHz IF bandwidth (goal 8 GHz).

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Sub-system	Component	HIFI	HERO
Local Oscillator	**Synthesizer Technology**	YIG-based Ka-Band+Active Frequency Multipliers + GaAs W-band power amps	CMOS or YIG-based W-band synthesizer + GaN. amps
	Multiplied LO	Cascaded GaAs frequency multipliers	Cascaded Mult ipl. + On-chip. Power Combining +. 3D integ.
	Pixels per array	1	9
	DC power/pixel	25 W	~ 1.5 W
	Fractional Bandwidth	~12 %	~45 %
Cryogenic Detectors	**Mixer Technology**	SIS, HEB	SIS, HEB
	SIS sensitivity	2 - 6 hν/k	2 hν/k
	HEB sensitivity	13-18 hν/k	3 hν/k
	LNA Technology	InP HEMT	Low-power SiGe HBT
	Number of pixels	1	2x9
	DC power/pixel	10 mW	0.5 mW
	Mixer. Assembly	Quasi-optical	Waveguide
Backend	**IF Processing**	GaAs HEMT amplifiers	
	Spectrometer Tech.	FFT FPG	CMOS based SoC
	DC Power/pixel	10 W	2W
	IF Bandwidth	1.5 GHz	6 GHz goal 8GHz
Total DC power per pixel		35 W	3.5 W

Fig. 1. HERO builds on the successful HIFI/Herschel mission, but carries it to new dimensions by proposing the first heterodyne array receiver for a satellite.

On a satellite, resources are scarce and we require a drastic reduction in cooling power and electrical power with improved instrument performance (see table above). HERO builds on promising recent developments, and we propose a dedicated technology roadmap to reach TRL 5 in 2025 for all components.

REFERENCES

[1] M. C. Wiedner et al., "*Proposed Heterodyne Receiver for the Origins Space Telescope* " *IEEE Trans. On THz Science and technology,* vol 8, issue 6, pp. 558-571.

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