WaFIRS, a Waveguide Far-IR Spectrometer

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From 0.1 to a few THz, incoherent and coherent detection methods overlap as the primary technology for astronomical observations. As astronomy at these frequencies shifts its focus from galactic to extragalactic objects with few hundred km/s linewidths, and possibly unknown redshifts, the total bandwidth of coherent receivers becomes a limitation. Incoherent spectrometers at these frequencies are often impractical for a different reason – the large cryogenic volume and mass required.

To help overcome the size limitations of current incoherent spectrometers, we are developing WaFIRS, a novel concept for long-wavelength spectroscopy which utilizes a parallel-plate waveguide and a curved diffraction grating. WaFIRS provides the large (~60%) instantaneous bandwidth and high throughput of a conventional grating system, but offers a dramatic reduction in volume and mass. WaFIRS requires no space overheads for extra optical elements beyond the diffraction grating itself, and is two-dimensional because the propagation is confined between two parallel plates. Thus several modules could be stacked to multiplex either spatially or in different frequency bands. The size and mass savings provide opportunities for spectroscopy from space-borne observatories which would be impractical with conventional spectrographs. We have built and tested Z-Spec, a WaFIRS prototype for 1-1.6 mm, and are currently constructing a 100 mK model with ~160 bolometers for a ground-based $\lambda/\Delta\lambda \sim 350$ submillimeter galaxy redshift machine.

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