

Z-SPEC: A BROADBAND MILLIMETER-WAVE SPECTROMETER

Glenn, J.¹, Ade, P.A.R.², Aguirre, J.¹,
Battle, J.³, Bock, J.J.³, Bradford, C.M.³,
Dragovan, M.⁴, Duband, L.⁵, Earle, L.¹,
Hristov, V.⁴, Maloney, P.¹, Matsuhara, H.⁶,
Naylor, B.⁴, Nguyen, H.³, Wood, C.¹, Zmuidzinas, J.⁴

¹University of Colorado

²Cardiff University

³Jet Propulsion Lab

⁴California Institute of Technology

⁵Commissariat à l'Énergie Atomique, France

⁶Institute of Space and Astronautical Science, Japan

Z-Spec is a broadband millimeter-wave spectrometer that is designed to serve two purposes: first, to measure redshifts of extremely luminous, dusty, high-redshift galaxies (submillimeter galaxies) to probe the cosmic history of star formation and super-massive black hole growth and second to demonstrate a compact waveguide-coupled diffraction grating technology for future space-borne far infrared platforms. Z-Spec has an instantaneous band from 0.97 mm (310 GHz) to 1.54 mm (195 GHz), matched to the 1 mm atmospheric transmission window. The corresponding spectral resolution range is 250 to 400, respectively. For the redshift range $1 \leq z \leq 3$, two to four CO lines will be present in the band, enabling unambiguous redshift determinations. At higher redshifts, lines of [CII], [NII], and [OI] will fall within the bandpass. The broad, instantaneous bandwidth will enable simultaneous calibration of all the spectral lines, eliminating a source of uncertainty in line fluxes.

Z-Spec's spectral resolution is achieved with a compact, waveguide-coupled Rowland diffraction grating with dimensions of 62 cm by 48 cm by 3.3 cm; it is a compromise between maximum desirable resolution (800 to resolve lines of galaxies) and a realistic cryogenic volume. The feedhorn-fed grating is comprised of a parallel-plate waveguide coupled to tapered rectangular waveguides that terminate at an array of 160 bolometers. Simulations of the electromagnetic propagation in the parallel-plate waveguide, the tapered waveguides, and the coupling between them were used to optimize the resolution and end-to-end optical efficiency, two challenging aspects of the system. The expected millimeter-wave background led to bolometer design NEPs of $4 \times 10^{-18} \text{ W Hz}^{-1/2}$, which necessitated a 50 mK base temperature. This is achieved with an adiabatic demagnetization refrigerator backed by a $^4\text{He}/^3\text{He}$ sorption refrigerator. The grating, which we have dubbed WaFIRS (Waveguide Far-Infrared Spectrometer), serves as a proof-of-concept for future far-infrared space platforms, including the 3.5-meter Japanese satellite SPICA and SAFIR.

We had an engineering run at the Caltech Submillimeter Observatory in June of 2005 and obtained spectra of a few evolved stars and the luminous infrared galaxy NGC 6240. Ultimately, we would like to observe with Z-Spec on the IRAM 30-meter telescope and the 50-meter LMT.

This work was supported in part by an NSF Career Grant and a Research Corporation Innovation Award to J.G., NASA grants NAG5-11911 and NAG5-12788, and matching funds from the University of Colorado, Boulder. L.E. gratefully acknowledges a NASA GSRP Fellowship.

Abstract Submission Form

2006 National Radio Science Meeting

Abstract: glenn15629

Date Received: September 18, 2005

1. (a)
Jason Glenn
CASA 389-UCB
University of Colorado
Boulder, CO
80309 USA
jglenn@casa.colorado.edu
(b) (303) 735-5904
(c) (303) 492-5941
2. J - Radio Astronomy
3. (a)
4. I - Invited Paper, Program chair:
C. K. Walker and Y.
Rahmat-Samii
5. No special instructions