ULTRA-WIDEBAND HETERODYNE SPECTROSCOPY

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Increasing mixer and front-end ampli_er bandwidths make heterodyne spectrometers with many gigahertz of instantaneous bandwidth possible. The science drivers for such instruments include millimeter-wave spectral searches for distant objects with poorly known redshifts, submillimeter and far-infrared observations of Doppler-broadened spectral lines from galaxies, and observations of pressure-broadened atmospheric lines. Modest spectral resolution is sufficient for these observations. A number of reasonably mature and proven technologies for broadband microwave spectrometers are suitable for astronomical spectroscopy (Harris 2003a,b provide brief reviews): acousto-optical spectrometers, digital correlation spectrometers, and analog correlation spectrometers. Here I summarize work on analog auto- and cross-correlation spectrometers, systems capable of ultra-wideband spectroscopy. Analog correlators obtain their wide bandwidths by a combination of transmission line delays and direct voltage multiplication in transistor or diode mixers. The WASP2 family of compact, low-power correlators have approximately 33 MHz resolution over 3.75 GHz bandwidth (Harris & Zmuidzinas 2001). Correlator bandwidth in these spectrometers is limited by the transistor multiplier circuit, and I show new results from a custom MMIC Gilbert-cell multiplier circuit that provides bandwidths of more than 20 GHz.

I discuss the astronomical and technical aspects of two concrete applications: a cascade of four WASP2s that provides 21 GHz spectral coverage with a 200{300 GHz wideband receiver at the Caltech Submillimeter Observatory, and a package of eight spectrometers that is under construction to cover the full 26{40 GHz Ka-band at the NRAO 100-meter Green Bank Telescope. Both of these systems are optimized for searches for high-redshift spectral lines from the carbon monoxide molecule. The GBT system will take advantage of the stability provided by correlation radiometery for ultra-wideband spectroscopy (Harris 2005). Observations with these spectrometers provide precise redshifts needed for high spatial resolution observations with millimeter- and centimeter-wave observations, and measure line uxes for radiative transfer models that constrain the physical conditions of young galaxies.

References

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