Wideband Lag Correlator for Heterodyne Spectroscopy

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1 Introduction

As sensitive superconducting mixers bring near-quantum-limited performance to ever higher frequencies, the need for wideband signal processing also increases. Important submillimeter and far-IR science targets include searches for high-z objects, observations of luminous distant galaxies, and measurements of pressure-broadened lines in planetary atmospheres. With the exception of pressure broadening, line widths are set by the sources' dynamics, so the bandwidth required for a measurement of a given object increases with frequency through the Doppler effect: $\Delta f = f \times V / c$ Amplifier and spectrometer bandwidths which are perfectly adequate at millimeter wavelengths may be woefully inadequate for the new receivers. Figure 1 shows bandwidth and resolution requirements for a wide range of astronomical sources. This figure emphasizes that spectrometers with bandwidths of a few GHz are necessary for extragalactic observations.

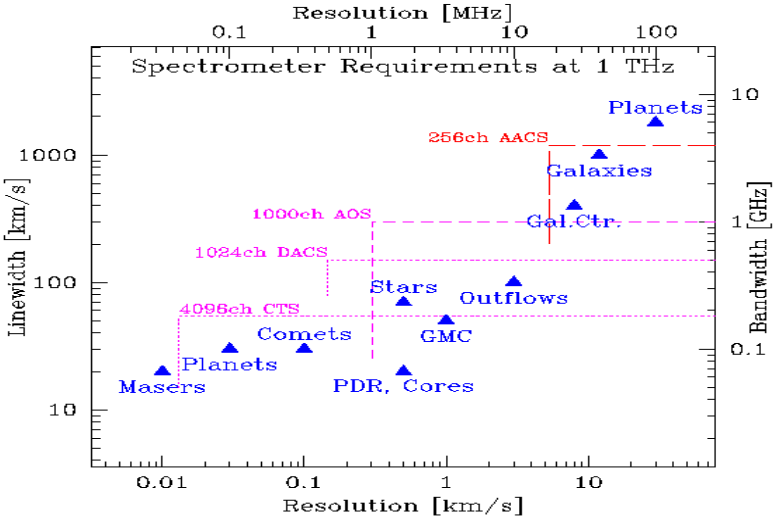

Figure 1

2 The WASP family of analog autocorrelation spectrometers

We have developed a family of wideband spectrometers with suitable bandwidth and resolution for submillimeter and far-IR observations of external galaxies from ground-based, airborne, and space platforms. These autocorrelation spectrometers obtain their bandwidth with fully analog high-frequency signal processing. Circuit boards contain all the components necessary to estimate the autocorrelation function $R(\tau) = \langle V(t) \times V(t+\tau) \rangle$. Tapped transmission lines provide the time delays τ, transistor multipliers form the product of the two input voltages $V(t)$ and $V(t+\tau)$, and low-frequency electronics integrate the multiplier outputs to provide the time average. Figure 2 shows schematic diagrams for the spectrometer and correlator board layout.

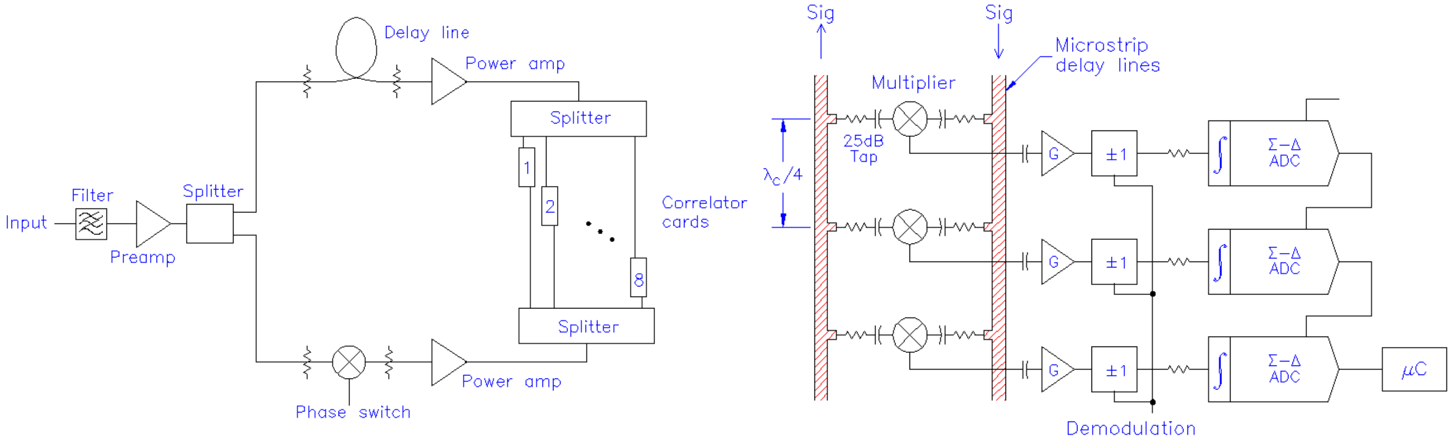

Figure 2

WASP2 has high performance:Figure 3 is a spectrum of the starburst galaxy M82 as an example. The spectrum fills only a fraction of the spectrometer's 3.6 GHz bandwidth. The spectrometer is compact and mounts next to the receiver; this, along with high electronic stability, allows it to integrate stably for many hours. WASP2's power consumption is very low as well: 40 W total, including the real-time digital data processing. The instrument is fully described in a paper by A.I. Harris and J. Zmuidzinas that has been submitted to the *Review of Scientific Instruments*.

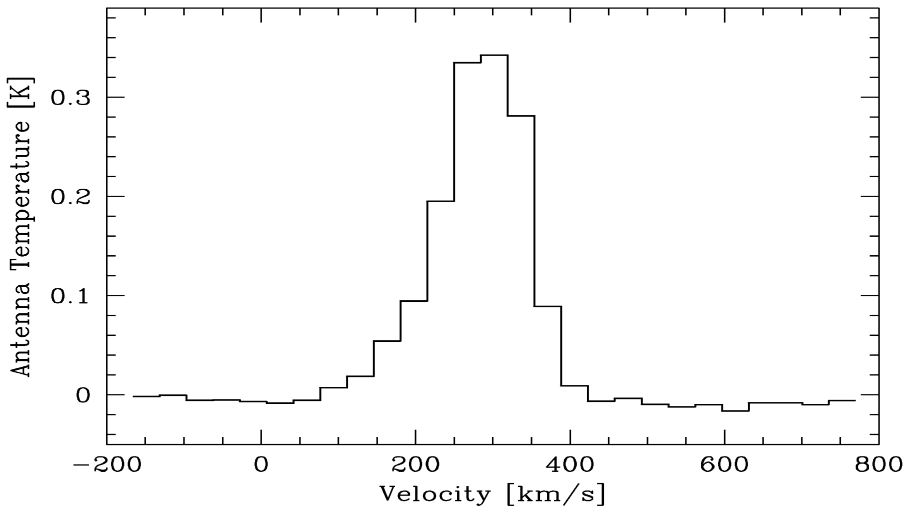

Figure 3

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