Abstract to the conference
Scientific Frontiers in Research on Extrasolar Planets
Washington DC, June 18-21, 2002

Interferometric Doppler Spectrometers: Principles and Results

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The Externally Dispersed Interferometer (EDI) is an enabling technology for sensitive, high velocity-precision Doppler detection of planets. The white-light interferometric spectrometer measures Doppler-shift dependent fringe patterns. The EDI velocimeter may be constructed by placing a phase-stepped Michelson interferometer at the slit-feed of an existing conventional or echelle spectrometer. EDI's large, simultaneous bandpass and high spectral resolution will allow for efficient Doppler planet surveys using under-utilized telescopes with smaller apertures and lower resolution spectrographs than those used for existing Doppler instruments. This is because EDI's high efficiency, large angular acceptance and focal-quality tolerance provide important advantages compared to classical grating, echelle or Fourier-transform spectrographs. The interferometer's large angular acceptance and tolerance to focal quality means that high precision measurements can be made with lower quality telescopes or poor seeing. The large angular acceptance also allows for the use of wavelength fiducial emission lamps that provide an otherwise unobtainable bandpass that is scientifically important and that yields high sensitivity.

We report on the continuation of our last 3-years of Doppler dispersed-interferometry work. We present an exact treatment of the system's sensitivity including instrumental and photon noise effects for both point sources and extended sources. The Doppler EDI sensitivity dependence on spectrograph resolution differs for extended and point sources. EDI sensitivity is compared to standard echelle-based Doppler instruments. We show an important breakthrough, that EDI can be operated in a uniform-phase configuration with a minimized slit-height that allows for simultaneous use over an entire echelle spectrometer's bandpass. Operating the EDI over an echelle's full bandwidth provides a huge increase in flux and therefore Doppler sensitivity. The uniform-phase method also allows for multi-object velocimetry which can be applied to effective field-object surveys. We present solar and stellar fringing spectra taken at the Lick observatory with an EDI uniform-phase arrangement of the CAT echelle spectrograph. These data show the predicted interferometric operation over the entire echelle spectrograph band. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.