A Spatial Heterodyne Spectrometer for Laboratory Astrophysics; First Interferogram

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Abstract

Spatial Heterodyne Spectrometer (SHS) designs have the potential to revolutionize interferometric spectroscopy in the VUV. The advantages of interferometric spectrometers such as the Kitt Peak 1m Fourier Transform Spectrometer (FTS) in the near UV, visible, and IR for laboratory measurements of spectroscopic data including emission branching fractions, improved level energies, and hyperfine/isotopic parameters are well documented. These advantages include: (1) very high spectral resolving powers, (2) excellent absolute wavenumber accuracy, (3) extremely broad spectral coverage, (4) high data collection rates, and (5) insensitivity to source drift during branching fraction measurements. We are designing and building a very broadband, high resolution VUV compatible SHS. In order to address certain design issues including scattered light, order separation, and phase stability in a broadband SHS, we have built a Phase 1 SHS with a transmitting beamsplitter. We are planning to start construction of an all reflection Phase 2 SHS in the near future. Our Phase 1 SHS has a CaF2 beamsplitter and a matched pair of very coarse (23.2 groove/mm) echelle gratings blazed for 63.5 degrees. Key mechanical components have temperature compensated designs and many parts, including the entire optical bread board, are made of Invar for long term phase stability. The 96 mm wide gratings blazed at 63.5 degrees are compatible with a limit-of-resolution of 0.125 cm-1 using a symmetric interferogram, and a smaller limit-of-resolution using an asymmetric interferogram. The localized fringes of equal thickness from a SHS should be straight and equally spaced. The fringes are imaged onto a CCD camera in an SHS. We are purchasing a 4 Mega-pixel VUV compatible CCD camera. The first interferograms from our Phase 1 SHS were recorded with an older 0.25 Mega-pixel VUV compatible CCD camera. These interferograms are quite satisfactory. The equally spaced straight fringes in our first interferograms are indication that the beamsplitter and grating surfaces are flat to a fraction of a wave. Optical imperfections are much more serious

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in a traditional Michelson FTS than in a SHS. We are anticipating some slight fringe deviations as our Phase 1 instrument is pushed to shorter (VUV) wavelengths, but small deviations can be corrected with software after transferring the interferogram from the CCD. Similar optical imperfections from either figure or index of refraction variations in a Michelson FTS lower fringe contrast and degrade the instrument sensitivity. The use of a CCD camera to record the spatially distributed interferogram means that the SHS is quite compatible with transient, low duty cycle sources which are common in the VUV.

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