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New use of Heterodyning in High Resolution Broadband Spectroscopy

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A novel technique for broadband high resolution spectroscopy is described, producing low photon noise, compact spectrometers with no moving parts suitable for airborne/spaceborne platforms or low cost instruments. One-dimensional imaging spectroscopy is possible. By combining a fixed delay interferometer with an external grating, a hybrid instrument is formed having the low photon noise of a purely dispersive spectrometer and the compactness of a purely interferometric spectrometer. The sinusoidal transmission of the interferometer heterodynes high details of the input spectrum down to produce broad features of a moire pattern, recorded by a CCD detector, which in data processing can be reconstituted to high detail. The low details are combined with the high details in analogy to the "tweeter" and "woofer" of a stereo speaker. In this way the effective spectral resolution can be several times greater than the grating used alone. The dispersion prevents adjacent wavelength channels from mixing and diminishing each other, increasing the photon limited signal to noise by more than an order of magnitude compared to Fourier Transform Spectrometers (FTS). Experimental demonstrations with a prototype measuring sunlight show excellent agreement with the textbook solar spectrum. How the technique differs from other spectroscopies, including previous grating-interferometer hybrids, will be described. 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.