Introducing tunable special heterodyne spectrometers in cometary studies heterodyne spectrometers in cometary studies

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Cometary remote sensing, in many cases, depends on measurement of fine spectral features from targets covering relatively large angular areas on the sky. The range of studies in cometary science is highly diverse. Size scales and perspectives vary dramatically, with opportunities for both Earth-based and *in situ* studies. Many characteristics of comets, such as coma dynamics, outflow/escape, radiative transfer, and isotopic ratios, are best addressed with high-resolving-power studies that integrate a large FOV. In addition, it is of great importance to obtain high-resolution data to resolve small Doppler shifts, fine structure, line shapes, and atomic multiplets/molecular bands. However, more detection is not enough, because the coma is inherently active; it can manifest substantial variation both temporally and spatially. As a result, we must combine a study of the target's global evolution parallel to the ability to measure with some spatial fidelity across the FOV and to map its variation in time. This combination of requirements is a challenge that modern instrumental approaches are limited in their ability to meet.

One method for addressing these needs is through the use of a broadly tunable all-reflective Special Heterodyne Spectrometer (SHS). SHS instruments are common-path two-beam Fourier-transform spectrometers that produce 2-D spatial interference patterns without the requirement for moving parts. The utility of SHS comes from its combination of a wide input acceptance angle (0.5–1°), high resolving power (of order $\sim 10^5$), compact format, high dynamic range, and relaxed optical tolerances compared with other interferometer designs. This combination makes them extremely useful for velocity-resolved observations of wide field targets from both small and large telescopes. We have constructed a tunable SHS, Khayyam, at fixed focal plane of the Coudé Auxiliary Telescope (CAT) at Mt. Hamilton. The CAT provides a test case for on-axis use of SHS, and the impact of the resulting field non-uniformity caused by the spider pattern will be discussed.

The major thrust of this project is to monitor isotopic and chemical ratios of comet volatiles, both of which are directly relatable to different aspects of early solar nebula and to the evolution and identification of heterogeneity in comet nuclei. The majority of cometary isotopic measurements come from a few well-characterized molecular species. In this work, we would present the preliminary observation results of CN, C_2, NH_2, Na, and O(1D) in comets C/2012 K1 (PanSTARRS) and C/2012 X1 (LINEAR) with the aim of characterizing production rate ratios, measuring Swings and Greenstein line shifts, and determining the C and N isotope fractionation. These ratios are thought to be tied directly to the original conditions of the solar nebula and protoplanetary disk and the stellar processing in the region where the Sun formed. The observational statistics on these types of studies are improving, but the limited sample is mainly due to the contradictory needs for high resolving power and s/n which has often limited studies to bright objects or to observations from large aperture observatories. Completion of Khayyam would provide a large temporal sample of data which would enable us to monitor isotopic and chemical ratios of comets at high resolving power and wide FOV.

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