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DEVELOPMENT OF WIND MEASUREMENT SYSTEMS FOR FUTURE SPACE MISSIONS

Abstract

An essential physical quantity for the understanding of planetary systems is dynamics; that is, atmospheric winds. Relatively few wind measurement missions have been conducted in past decades, but there is current renewed interest. This presentation is concerned with optical remote sensing methods; other in-situ approaches, such as the measurement of atmospheric drag on satellites are not included. The optical methods are based on Doppler shifts of atmospheric emission or absorption features. Accurate measurements, say to 3 m/s are, when compared with the velocity of light, one part in 10exp(8). This puts a requirement on spectral resolving power, R, which turns the focus to the inherent superiority of optical systems, defined as ΩR, where Ω is the solid angle of the field of view associated with the measurement. This quantity is constant for most spectroscopic instruments, meaning that if large R is required, Ω must be small, and in turn this means that less light is collected. This presentation considers three classes of optical spectroscopic systems, the Fabry-Perot Spectrometer (FPS), the Doppler Michelson Imager (DMI) and the Spatial Heterodyne Spectrometer (SHS). The FPS is a quadratic system, in that the change of wavelength corresponding to a change of off-axis angle inside the instrument goes as the square of the angle. The DMI is a fourth-order system, allowing higher values of Ω, and thus of superiority, for a given R and the same is true of the SHS. Recent advances in technology have significantly increased the capability of the measurements. CCD detectors have quantum efficiencies approaching unity. Similarly, the transmittances of interference filters can also be in the range 50 to 80 percent; for both, further improvements are extremely limited. Thus enhancements will not come from technology improvements, but from optimization of configurations. The responsivity of the optical system goes as AΩ, where A is the area of the aperture viewing into Ω so where size is not limited there is no problem. The future wants smaller instruments and larger Ω means a smaller instrument, which is good, but the larger Ω may be much larger than that of the target, so a telescope is required to couple the two. The ultimate field of view depends on the pointing ability of the instrument or spacecraft to track the target, such as the limb of a planet. Examples of new results from past missions are presented and possible directions for future missions described.