**Comparing Near-Surface and Bulk Densities of Comets Using Radar Scattering Properties.** L.F. Zambrano-Marín1,2, A. Virkki3, E.G. Rivera-Valenti3,4, Escuela Internacional de Posgrado, Universidad de Granada, 5Areceibo Observatory, Universities Space Research Association, HC 3 Box 53995, Arecibo, PR 00612, USA (luisafz@correo.ugr.es)

**Introduction:** Ground-based radar observations of comets and asteroids are an accurate, cost-efficient way to obtain information on their dynamical and physical properties. In a dual-polarization radar measurement, the echo is received in two parts: one in the opposite circular (OC) sense to the transmitted signal and the other in the same circular (SC) sense as that transmitted. The ratio of the integrated echo power in SC sense to that in the OC sense is called the circular-polarization ratio μc, which provides a constraint on surface roughness of the target. For comets, μc is typically from 0.1 to 0.6. The radar albedo describes the radar reflectivity of the target per unit area. Several studies [1,2,6] have shown the connection of the (OC) radar albedo to the abundance of metals and the surface density of the target. The radar albedo of comets is somewhat lower than that of asteroids, typically 0.04-0.1[1]. Spacecraft measurements [3,4] have shown some of the dust grains can be of silicates like olivine or enstatite, both minerals with higher density than water ice (~ 3 g/cm^3 vs 0.92 g/cm^3). Microporosity of comets is closely related to the mix of dust and ice particles comprising the comet. Having an estimate for the near-surface bulk density derived from radar data gives an opportunity to get implications on the evolutionary history of the object. Cometary surfaces suffer continuous transformation; constant mass loss is evident in the form of the comet’s coma. The radar cross section of the coma can be used to estimate the mass loss rate of large coma particles [1]. The continuous, active surface processes make cometary surface studies a very dynamic field. Near surface, solid density and bulk density calculations from radar data aid in accounting for the comet’s nucleus and grain density of coma. Radar signal can easily penetrate through highly porous surfaces and therefore measure radar albedos that arise from materials which are not visible to optical wavelengths. For example the Rosetta mission failed to find visible, major patches of ice on the surface of the comet Churyumov-Gerasimenko by imaging. However, radar measurements have found deposits of ice in the subsurface [7].

**Methods:** Harmon et al. obtained boundaries on radar albedo (σ) of the nucleus and surface densities by comparing the cross section of the nucleus with independent size estimates. In the same work it is suggested that the radar-wavelength-scale particles in the coma contribute to the radar echo[1]. For μc near zero the OC radar albedo (σ) is the first order estimate of the Fresnel power reflection coefficient R, which depends on the bulk density [2]. Magri et al. (2001) presented the Fresnel reflectivity (R) written in terms of the radar albedo σ (opposite-sense quasi-specular radar albedo σ_{OC-qS}) and backscatter gain g (σ=gR). We use the equation for measurable radar properties, obtaining a formula for near-surface bulk density for porous, unconsolidated, dry powders based on Fresnel reflectivity. A comet's solid density refers to the bulk density of the object over its porosity (d_{bulk} = (1-p) d_{solid}). With some assumptions about the amount of diffuse scattering and backscatter gain we can give an estimate of the near-surface bulk density and/or solid density which can be compared to spacecraft measurements and published values for the selected targets. For this study, we selected 103P/Hartley 2, C/2001 A2, P/Encke, 26P/Grigg-Skjellerup, C/1983H1 (IRAS-Araki-Alcock), C/1983J1 (Sugano-Saigusa-Fujikawa), C/1996B2 (Hyakutake), C/1998K5 (Linear), P/2005JQ5 (Catalina), 67P/Churyumov-Gerasimenko, 209P/Linear, and 8P/Tuttle. In this paper we estimate the physical properties of the cometary surfaces based on radar observations. We estimate the near-surface density and porosity using the radar albedos and circular polarization ratios and compare the results to the published values when applicable, i.e., for comets that have been visited by spacecrafts.

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