Geophysical Research Abstracts
Vol. 12, EGU2010-12503-2, 2010
EGU General Assembly 2010

New Evidence from Silica Debris Exo-Systems for Planet Building Hypervelocity Impacts

Carey Lisse and the Circumstellar Silica Exo-Dust Team
Applied Physics Laboratory, Johns Hopkins University (carey.lisse@jhuapl.edu)

There is abundant inferential evidence for massive collisions in the early solar system [1]: Mercury's high density; Venus' retrograde spin; Earth's Moon; Mars' North/South hemispherical cratering anisotropy; Vesta's igneous origin [2]; brecciation in meteorites [3]; and Uranus' spin axis located near the plane of the ecliptic. Recent work [4] analyzing *Spitzer* mid-IR spectra has demonstrated the presence of large amounts of amorphous silica and SiO gas produced by a recent (within 10^3 – 10^4 yrs) large ($M_{Excess} > M_{Pluto}$) hypervelocity impact collision around the young ($\sim$12 Myr old) nearby star HD172555, at the right age to form rocky planets. Many questions still remain concerning the location, lifetime, and source of the detected silica/SiO gas, which should not be stable in orbit at the estimated 5.8 AU from the HD172555 A5V primary for more than a few decades, yet it is also highly unlikely that we are fortuitously observing these systems immediately after silica formation **A** tabulation of the amount counts in the fine silica dust is decidedly Fe and Mg-atom poor compared to solar [4].

Three possible origins for the observed silica/SiO gas seem currently plausible :

(1) A single hyperevelocity impact (>10km/s in order to produce silica and vaporize SiO at impact) creating an optically thick circumplanetary debris ring which is overflowing or releasing silica-rich material from its Hill sphere. Like terrestrial tektites, the Fe/Mg poor amorphous silica rubble is formed from quick-quenched molten/vaporized rock created during the impact. The amount of dust detected in the HD172555 system is easily enough to fill and overflow the Hill sphere radius of 0.03 AU for a Pluto-sized body at 5.8 AU from an A5 star, unless it is optically thick (> 1 cm in physical depth). Such a disk would provide a substantial fraction of the observed IR flux, and will be dense enough to self-shield its SiO gas, greatly extending its photolytic lifetime. The lifetime for such a system versus re-condensation into a solid body like the Moon is short, though, $\sim 10^3$ to 10^4 yrs [5]. Credence is lent to this scenario by observations of the Jovian impact in July 2009 [6], where absorption features due to silica have been found superimposed on those of hot ammonia at the > 60 km/s impact site (Fig. 1).

(2) Ongoing multiple small hypervelocity impacts continuously grinding down a distribution of large circumstellar particles above the blowout size limit (the "rubble" identified in [4]) and releasing silica rich material and SiO gas. This model would require a massive (>1 M_{Moon}) belt of 10 μm – 1 cm particles with inclinations spread out over at least $\pm 45^o$ [4] or dust on highly eccentric orbits [7]. The amount of material implied by the relative amplitude of the rubble spectral feature is consistent with the amount needed to collisionally produce the fine silica dust [4, 8]. A body rapidly re-accreting in a debris ring after collisional disruption (like the Moon) would have similar behavior (lots of impacts for some time, producing gas and little melt droplets).

(3) A single impact onto a silica-rich object with already highly differentiated surface layers. For a very young system at 10 - 20 Myr when we expect planets to be rapidly accreting, a Mercury or larger-sized rocky body covered in an SiO rich magma ocean is very likely by the Jeans energy criterion [9], even without considering additional heating input by ^{26}Al and other radioactives. For the lowest expected impact velocities, $v_{MercuryEscape}$ = 4 km/s, a pre-existing magma ocean in equilibrium with a surrounding SiO atmosphere would be required; at higher velocities the impacting body could be the formative mechanism for the magma ocean [10].

Further evidence for excess circumstellar emission due to silica dust have now been found. The youngest of these, HD154263, at $\sim$20 Myr age shows evidence for SiO gas and amorphous + crystalline silica. The 2 older systems, HD23514 at $\sim$100 Myr age, and HD15407 at $\sim$2 Gyr, conspicuously do not show any evidence for SiO gas while exhibiting strong features mainly due to crystalline silica. HD23514 also shows evidence for large amounts of amorphous carbon, PAHs, and nanodiamonds, due to a strongly enhanced C-atom abundance in impactor or impactee. HD15407, the oldest system, also does not show any conclusive evidence for the presence of large dark particles (“rubble”).