Star System HD172555 - Spectral Evidence of Abundant Silica Created by a Massive In-System Collision? -
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Introduction: HD172555 is an A5 IV/V star at 29.2 pc from the Earth, and as a member of the β Pic moving group, is estimated to be very young, ~12Myr [1]. What makes this star system stand out initially is the large amount of IR-radiation coming from it : in terms of the fractional luminosity of the dust, f/f_{max} is ~100 [2], which is quite extreme compared to the IR emission found around other A stars, even those with circumstellar disks. The overall spectral energy distribution (Figure 1) has a best-fit blackbody temperature of ~260K, which means the dust is relatively warm and located at around 3-4AU from the primary. The system also contains a wide binary companion, an M0 star CD -64 1208 at ~2000AU, and while the companion may dynamically limit the extent of any large dust orbits, it is not important with respect to the energy budget of the warm dust.

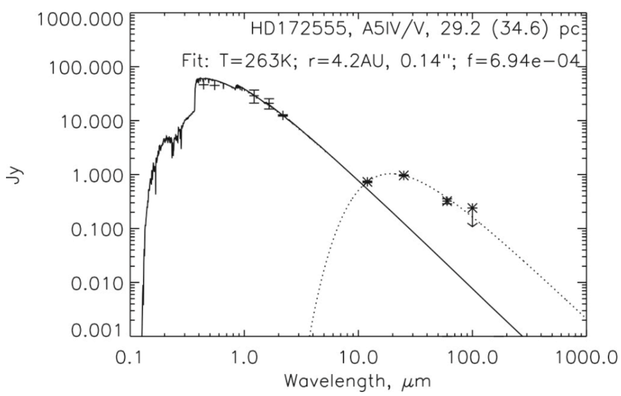

Figure 1 - BVR/2MASS/IRAS SED for HD172555 showing large, cold IR excess with T ~260K.

Warm Silica Dust ?: Warm dust is found only 1-2% of stellar systems older than 10 Myr [3], and implies that something special is going on in the system. From the models of Wyatt et al. [4], the observed circum-stellar dust does not need to be transient, particularly given its young age. By comparison of the overall mid-IR flux to that observed in other systems, it is likely that what is being observed is either a planetisimal belt which has recently been stimulated into a collisional cascade, or the result of a recent collision between two planetisimals. The small grains implied by the *Spitzer* Space Telescope IRS spectrum [2] support a recent collision model, as they are small enough to be expelled by radiation pressure and collisional modeling on the time scales of months.

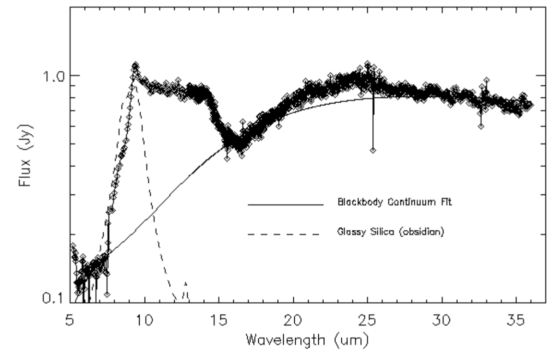

Figure 2 - Spitzer IRS spectrum of HD 17255 excess.

What makes the system really interesting is the shape of the spectral features (or lack thereof) in the 5-35 um Spitzer IRS spectrum [2] (Figure 2). There is a clear peak due to olivine at 11.2 um, and some smaller possible features at ~20 and 33 um also due to olivine, that are usually found in astrophysical spectra of YSOs and comets. There is also evidence for pyroxene in the dust spectra, with emission peaking at 9.5 - 11 um, and very abundant metal sulfides at 25 - 35 um. What is totally new, though, is the dominance of emission in the 8 - 9 um region, and a very strong peak at 9.3 um. Olivines and pyroxenes do not have substantial emission in this range but amorphous and crystalline silicas ($n*SiO_2$) do. In preliminary fits, a good match to this new emission feature is found with powdered obsidian. We can rule out massive amounts of PAHS as the source of the emission, by spectral modeling and direct comparison to the PAH-rich HD100546 system (Figure 3).

Physical Implications: If this indeed the spectral signature of silica, then, according to preliminary models, there is a significant amount of this material in the system, roughly the mass of a 50 km radius asteroid, dominating the sources of Si and O in the dust. About the same amount of mass again is present in metal sulfides. Evidence for silica has not been reported in cometary dust or in other circumstellar dust systems past the T Tauri stage. Comparison to other astrophysically similar spectra of comparable quality (Figure 3) verifies the unusual nature of the HD 172555. Some of these other systems, like HD69830 (fragmentation of the equivalent of a 30 km radius P or D asteroid at 2 Gyr, [5,6]) and HD113766 (fragmentation of the equivalent of > 300 km S-type asteroid, [7]) have been implicated as having dust due to collisional processes. Why is the HD17255 system so unusual, then?

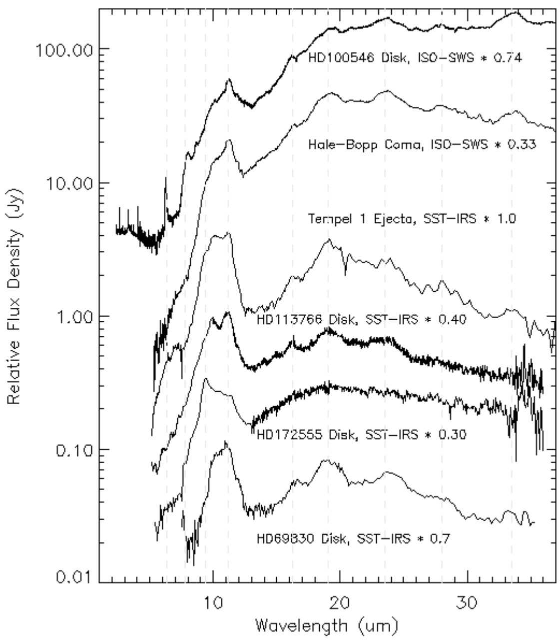

Figure 3 - Comparison of the mid-IR spectra of HD 172555 with the spectra of dust from: 2 comets (Hale-Bopp and Tempel 1); from a young, organic rich Herbig A0 star building a giant planet (HD100546); from a young F5 star building a terrestrial planet (HD113766); and with a mature main sequence star with a dense zodiacal cloud (HD69830).

Formation Processes : Our current working hypothesis is that the silica spectral signature is real, and that the silica has been created by a huge hypervelocity impact, via processes similar to those leading to the shocked quartz grains found at terrestrial impact craters. This impact massively disrupted the colliding body(s), and released a massive amount of metal sulfides from a core. The results of this collision are being seen soon after the impact, so there has been little time for the silica material to relax to the more thermodynamically stable olivine and pyroxene materials, or to be superceded by the products of subsequent grinding of macroscopic fragments. Hypervelocity impacts with enough mass could occur in a lunar formation event between large differentiated planetisimals (predictions of the short term recondensation products from a lunar formation event would be very interesting to compare to the observed spectra), or by destabilization of an asteroid belt due to planetary migration and subsequent multiple impacts onto body(s) in another part of the system. By contrast, the collisional processes that produced the dust detected in the HD69830 and HD113766 systems happened at much lower velocities, within a planetisimal belt, and occur much more frequently due to the high density of objects localized in a small region of space. One consequence of this hypothesis is that the silica dust in the HD172555 system should be relatively transient in nature. Another consequence is that we can use the presence of a strong mid-IR 8-9 um silica feature to locate massive hypervelocity events in exo-solar systems. There is some indication, for example, that the 400 Myr old system BD+20 307 [8] and the 100 Myr old HD 23514 [9], reported to have massive amounts of dust created by binary collisions [8], also demonstrate strong ~9 um emission spectral features [9].

References:

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