The Transiting Exocomets in the HD 172555 System

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The Earth is thought to have formed dry, in a part of the Solar Nebula deficient in organic material, and to have acquired its organics and water through bombardment by minor bodies. Observations of this process in well-dated systems can provide insight into the probable origin and composition of the bombarding parent bodies. Transiting cometary activity has previously been reported in Ca II for the late-A member of the ~24±1 Myr old β Pictoris Moving Group member, HD 172555 (Kiefer et al. 2014). We present HST STIS and COS spectra of HD 172555 demonstrating that the star has chromospheric emission and variable infalling gas features in transitions of silicon and carbon ions at times when no Fe II absorption is seen in the UV data, and no Ca II absorption is seen in contemporary optical spectra. The lack of CO absorption and stable gas absorption at the system velocity is consistent with the absence of a cold Kuiper belt analog (Riviere-Marichalar et al. 2012) in this system. The presence of infall in some species at one epoch and others at different epochs suggests that, like β Pictoris, there may be more than one family of exocomets. If perturbed into star-grazing orbits by the same mechanism as for β Pic, these data suggest that the wide planet frequency among A-early F stars in the βPMG is at least 37.5%, well above the frequency estimated for young moving groups independent of host star spectral type.

II. HD 172555 – β Pic's Evil Twin

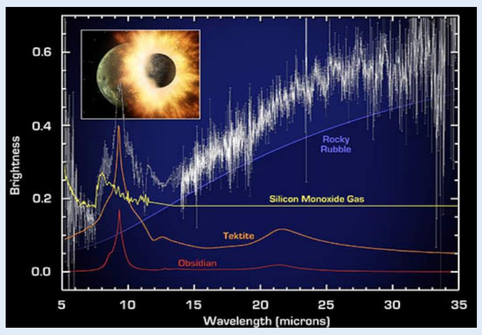
• A6V, T_{eff}=7800±200 K, d=29.2 pc (Riviere-Marichalar et al. 2012), member βPMG, age 24±3 Myr (Bell & Mamajek 2015). Star is co-moving with CD-64° 1208 (K5Ve, Feigelson et al. 2006

• [O I] emission seen by Herschel (Riviere-Marichalar et al. 2012) rather than more common [C II].

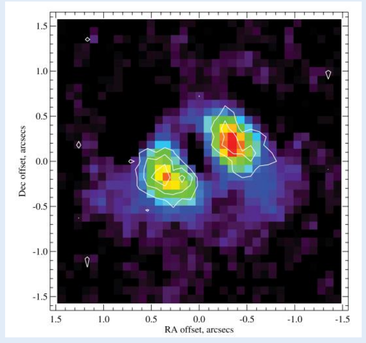
• Silica and SiO emission near 10 microns (Lisse et al. 2009, but see Wilson et al. 2016), suggestive of a hypervelocity impact.

• Infrared excess consistent with only warm dust (280 K blackbody) in the system (Riviere-Marichalar et al. 2012)

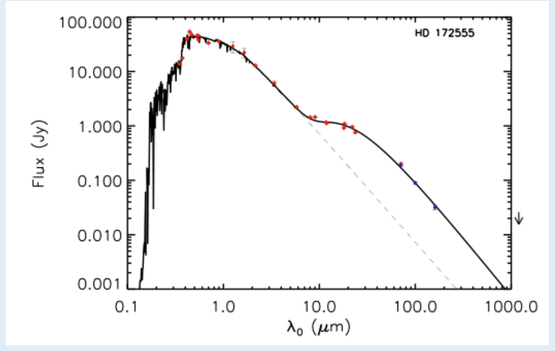
• Small disk to 24 AU observed at Q (Smith et al. 2012), inferred inclination i~75°.



Spitzer press release for Lisse et al. 2009



Smith et al. 2012



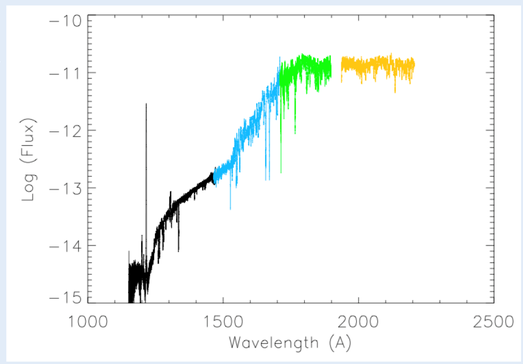
Riviere-Marichalar et al. 2012

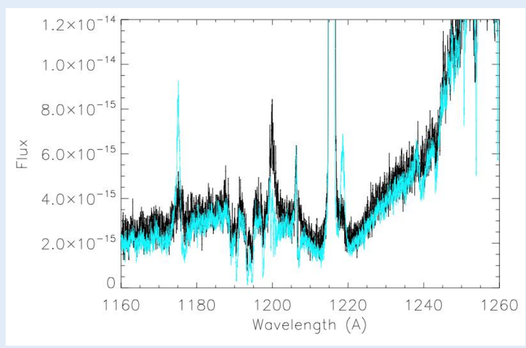
III. HD 172555 is an Active Star

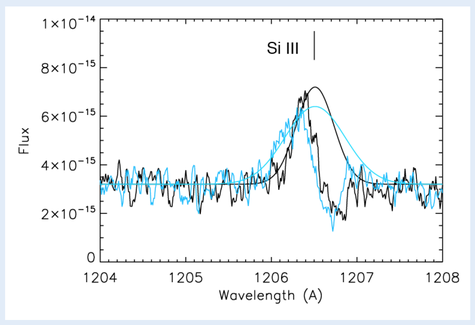
• HST STIS and COS observed HD 172555 on April 17 and 23rd 2015, in two visits separated by nearly 6 days. The spectra span 5 orders of magnitude in flux. The data were obtained on the dayside of HST's orbit, and have airglow contamination in N I, H I Lyman α, and O I.

• Weak circumstellar emission is seen in C III 1176 Å, stronger and variable emission in Si III 1206 Å, and after comparison with α Cep, in C II. The emission is observed on the short wavelength side of the spectral lines.

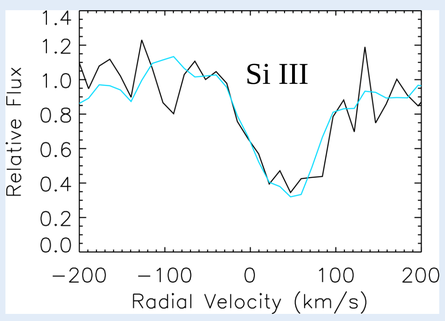
• The profiles closely resemble those seen in β Pic (right, in cyan).

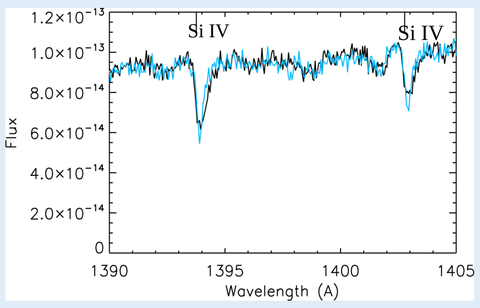






IV. Silicon Ions

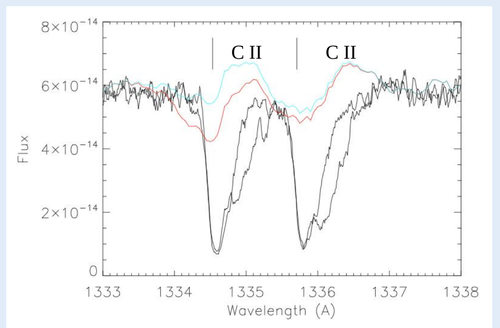




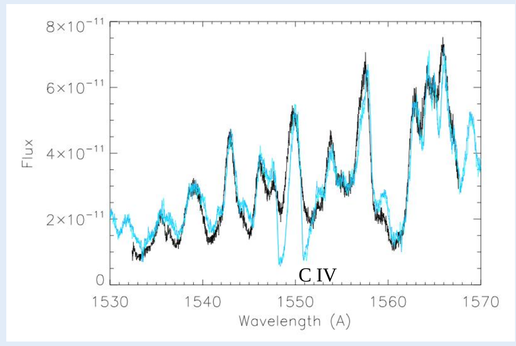
• Circumstellar Si II absorption not seen.
• Si III, after normalization by continuum + model emission, has the redshifted, flat-bottomed profile typical of falling evaporating bodies, with the absorption consistent with optically thick material occulting 60±10% of the stellar disk. No absorption variability is seen in the 2015 data.
• Si IV, is optically thin, and may also be not significantly variable.

V. Carbon

• We find variable C II absorption in the COS and STIS data. Absorption to red of line center. Compared α Cep (red) emission is present in both COS spectra. After normalization by α Cep, the absorption profiles have peak covering factors of 80%. The ratio of the visit 1 data to Visit 2 is 40%, and the same for both transitions, indicating the gas is optically thick



• Comparison with Altair shows excess absorption at C IV, with comparable depth in both transitions. Altair is not the best comparison source for HD 172555, but is the only option in the HST archives.



VI. Siderophiles and Super-Refractory Elements

• No significant circumstellar absorption is seen in Fe II 1608 Å, Al II 1670 Å, or Al III 1854, 1862 Å . This is consistent with an absence of Ca II FEB absorption in the same week.

VII. O I and H I

• Emission wings of HI can be seen against geocoronal emission, but unlike β Pic, no absorption at v≥200 km/s.

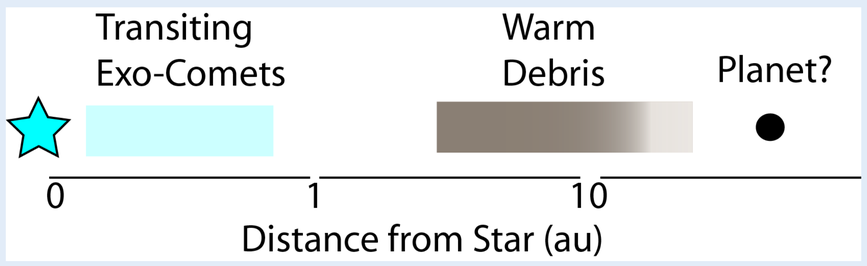
• Interstellar and low velocity O I absorption are visible against airglow emission, but at low S/N.

VII. Implications

• The redshifted features in the spectrum of HD 172555 are consistent with transiting star-grazing bodies, similar to those seen in β Pic (see review by Beust 2014), 49 Cet (Miles et al. 2016), and the Jupiter-family sun-grazing comets seen by SOHO (Beust 2014).

• We find abundant lithophile (silicon) absorption, and carbon. Airglow contamination of the COS data precludes study of water ice dissociation products H I and O I, so at present we cannot distinguish between parent bodies with cometary or asteroidal composition. The weakness or absence of superrefractory elements in the falling evaporating body spectra, and the pesence of silicon and carbon suggests bodies which may differ from those reported by Kiefer et al. (2014) and potentially resembling bodies in our outer asteroid belt.

• The architecture of the HD 172555 system appears to be:



• First steps toward disk tomography: The absence of CO absorption and a CS gas component at the system velocity indicate that features typical of debris disks with Kuiper belt analogs are not required for detection of star-grazing exo-comet activity.

• HD 172555 is the second system in the BPMG with transiting star-grazing bodies and lots of carbon.
• If the same mechanism proposed for β Pic is operating in this system, there is likely a planet exciting bodies in mean motion resonance into star-grazing orbits.
• Combined with 51 Eri, an early F star member of the BPMG, the giant planet frequency among the A-early F star members of the Moving Group may reach 37.5%, a rate far in excess of young associations as a whole, which is closer to 2% for objects more luminous than 5 Jupiter masses (Tamura 2016).

This work, in part, is based on observations made with the NASA/ESA *Hubble Space Telescope*, obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. New observations presented here were obtained under HST-GO-13798.