

04.03

A Brown Dwarf Companion as an Explanation of the Asymmetry in the Beta Pictoris Disk

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The optically observed edge-on disk in β - Pictoris has recently been found to be asymmetric with the NE branch extending to ≈ 1150 AU and the SW branch extending to only ≈ 900 AU (B. Smith, personal communication). The collision time scale of those particles which dominate the optical properties of the disk is given by $t_c \approx (\Omega \tau_v)^{-1}$ where Ω is the Keplerian angular frequency and τ_v is the vertical optical depth. At radii of 200 AU (approximately where the asymmetry begins) to 400 AU the measured chord optical depth, $\tau_c \approx \tau_v (Z/R)$, shows that $t_c \ll t_* =$ the age of the system. Extrapolating τ_c between 400 AU and 1000 AU also indicates that $t_c < t_*$ over this range of radii. Since any asymmetries in an isolated disk are expected to dissipate in a time $\sim t_c$, the observed asymmetry in β - Pic would seem to require a forcing agent. (Gravitational instabilities seem an unlikely explanation unless the disk is unexpectedly massive). Therefore, we have numerically investigated the possibility that the asymmetry is due to a sub-stellar companion in a non-circular orbit. The flatness of the disk indicates that the perturber should lie near the plane of the disk. We will present the range of brown dwarf masses, semimajor axes, and eccentricities which can account for the asymmetry.

04.04

The Spatial Scale, Characteristic Particle Size, and Evolution of the Particle Clouds around β Pic, α PsA, and α Lyr

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Simple models have been constructed of the IR emitting regions around β Pic, α PsA, and α Lyr. Central depleted regions with radii of order 20 AU are indicated in each case. The position of the inner boundaries in the cases of α Lyr and β Pic are well interior to the radius defined by relatively rapid sublimation of water ice particles. One possible explanation for maintenance of such a boundary would be a massive body orbiting at that radius, sweeping up particles entering the region. The relative importance of collisions versus radiation pressure effects as particle removal mechanisms and their relation to questions regarding the history of the particles will be discussed. The three particle clouds show a relation between total particle area and minimum particle size which suggests a process that progressively removes the smallest particles without replacement.

04.05

Modeling the Circumstellar Matter Around Beta Pictoris and other Nearby Main Sequence Stars

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We have modeled the IRAS IR excesses around the (old) main sequence stars β - Pic, α - Lyr, α - PsA, and ϵ - Eri. The disks in these systems are found to contain significant inner gaps. These gaps can be maintained against the Poynting-Robertson inward drift of small particles either by planets or by the sublimation of ices. We will present the required minimum planet masses and semimajor axes for the planetary model and the required grain size and inefficiency for the sublimation

model. The IR modeling and the collision physics both imply that the observed particles in β - Pic are small ($\sim 1\mu\text{m}$) and inefficient. A size distribution of such grains will necessarily have large relative velocities due to the size dependence of the radial radiation force. However, optical chronograph images (B. Smith personal communication) show that the disk in β - Pic is extremely flat (≤ 50 AU in half thickness at 1150 AU) which is inconsistent with significant relative velocities ($\gtrsim 0.1 V_{\text{KEP}}$). This problem and other apparent discrepancies between the optical and IR data may indicate that the scattering (optical) and absorbing (IR) particles correspond to two distinct populations. Other alternative explanations will be discussed.

04.06

Direct Imaging of Extra-Solar Planetary Systems With a Low-Scattered Light Telescope

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In order to achieve the goals of remotely detecting and characterizing extra-solar planets, the direct light from the planet must be examined without contamination from the light of the parent star. Only direct methods of planet detection are suited for obtaining these observations. One such method, which could be implemented with current state-of-the-art technology, is the Circumstellar Imaging Telescope (CIT). This is an Earth orbital, low-scattered light, coronagraphic telescope currently under study at the Jet Propulsion Laboratory and Perkin-Elmer. This telescope uses a combination of a coronagraph to reduce the diffraction of starlight by the telescope and a super-smooth mirror to reduce scattered light. By optimizing the coronagraphic optics we find that a reduction of diffracted light by a factor of over 1000 is possible. This would require a primary mirror about 15 times smoother than the Hubble Space Telescope primary at mid-spatial frequencies in order to reduce scattered light sufficiently to utilize the high coronagraphic efficiency. Current fabrication and metrology techniques allow the mass production of 0.5 meter diameter spherical primaries 5 times smoother than HST. We are currently fabricating test components in order to see how much further these techniques can be carried. Initial results indicate that current technology can produce the required optical components for this super-smooth telescope. Other non-conventional manufacturing techniques currently under study, could produce even smoother mirror surfaces and would further improve the performance of an extra-solar planet detecting and characterizing telescope. We find that a 1.5 meter diameter instrument in Earth orbit, would allow a broad range of science goals including the direct detection of a Jupiter-size planet around a solar type star out to a distance of about 10 parsecs. These same techniques could be employed on a larger instrument of 10 meters in diameter to detect the Earth out to these distances.

04.07

On the Feasibility of Direct Extra-solar Planet Detection using Hubble Space Telescope

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Detecting an extra-solar planet in reflected stellar radiation is an exceedingly challenging task. If two close point-sources of greatly different flux are imaged onto a detector, the fainter is discovered only if the signal near its location is convincingly larger than expected or observed in its absence. The implications of this criterion have been developed in terms of (1) the expected range of stellar and planetary