Stellar Wobble by a Planet in a Disk
Limitation on Planet Detection by Astrometry
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Summary
- We consider the possibility of planet detection by astrometry.
- SIM has enough accuracy (1 μ as) to detect infant planets at star forming regions.
- Light from a circumstellar disk shifts the photo-center of the star-disk system, and may interfere with the astrometry to measure precise stellar positions.
- The disk light causes a photo-center shift as large as the amplitude of the dynamical stellar wobble by a Jupiter mass planet.
- However, SIM is not sensitive to extended disk’s light, so the disk’s contamination to the astrometry shift is less than 1 μ as.

1. SIM: Space Interferometry Mission
Launch: 2009
Baseline: 10 m
Telescopes: 33 cm
Relative Accuracy: 1 μ as

2. Stellar Wobble by a Planet
Astrometry shift by a Jupiter mass planet
36 μ as at 140 pc > 1 μ as of the SIM accuracy
Search for infant planets is possible
Taurus-Auriga molecular clouds
~200 T Tauri stars (Kenyon & Hartmann 1995)
D=140 pc
10¹ – 10⁷ yr
At which epoch in young stellar evolution are planets born?

3. Disk’s Contamination
Dynamically
Shift of the mass-center
Optically
Shift of the photo-center
beam size >> disk’s diameter

4. Density Wave Pattern
Linear calculation
2-D disks
A gap in the disk [0.6rₚ – 1.4rₚ] 1-10 Mⱼ
Circular and co-planer orbits

5. Dynamical Shift
Disk’s dynamical effect is negligible even for a massive (0.16 Mo) disk

6. Optical Shift
Hydrostatic equilibrium in the z-direction
\[ h = \sqrt{\frac{2\gamma \Omega}{\eta}} \]
Images of the disk’s scattered light
- At optical wavelengths (400-900 nm)
- Disk surface is modeled as being solid
- Totally scattered starlight at the surface
- Illuminating and shadowing the surface
Wobble of the photo-center
Disk contamination is not significant if M > 10 Mⱼ

7. SIM Astrometry
SIM astrometry is not sensitive to extended sources larger than the fringe size,
\[ \lambda = 10 \mu \text{m, } 2\lambda = 3 \text{AU} \]
Disk contamination to the astrometry shift is less than 1 μ as for a 1 Mⱼ planet.