Jet Propulsion Laboratory
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Kuiper Belts & Debris Disks

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AFTA Coronagraph Workshop, Princeton Univ.

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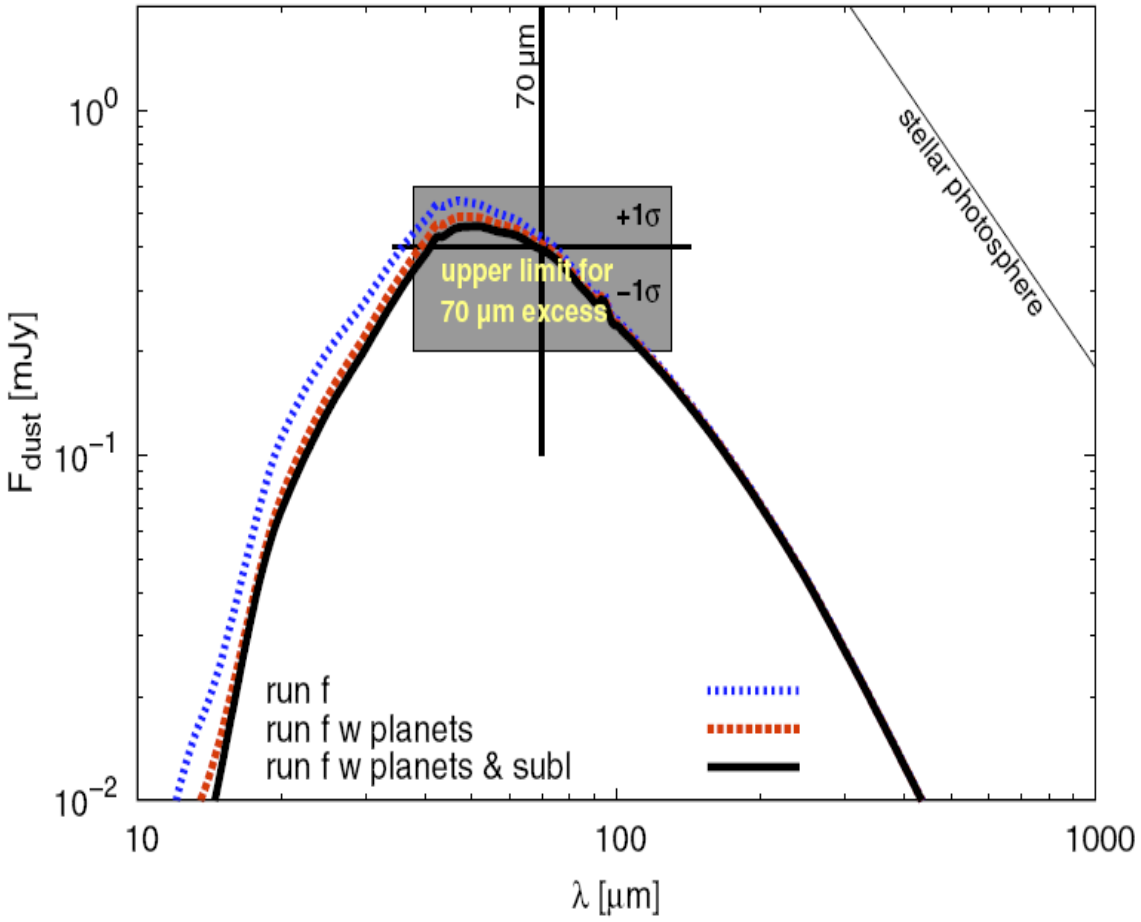
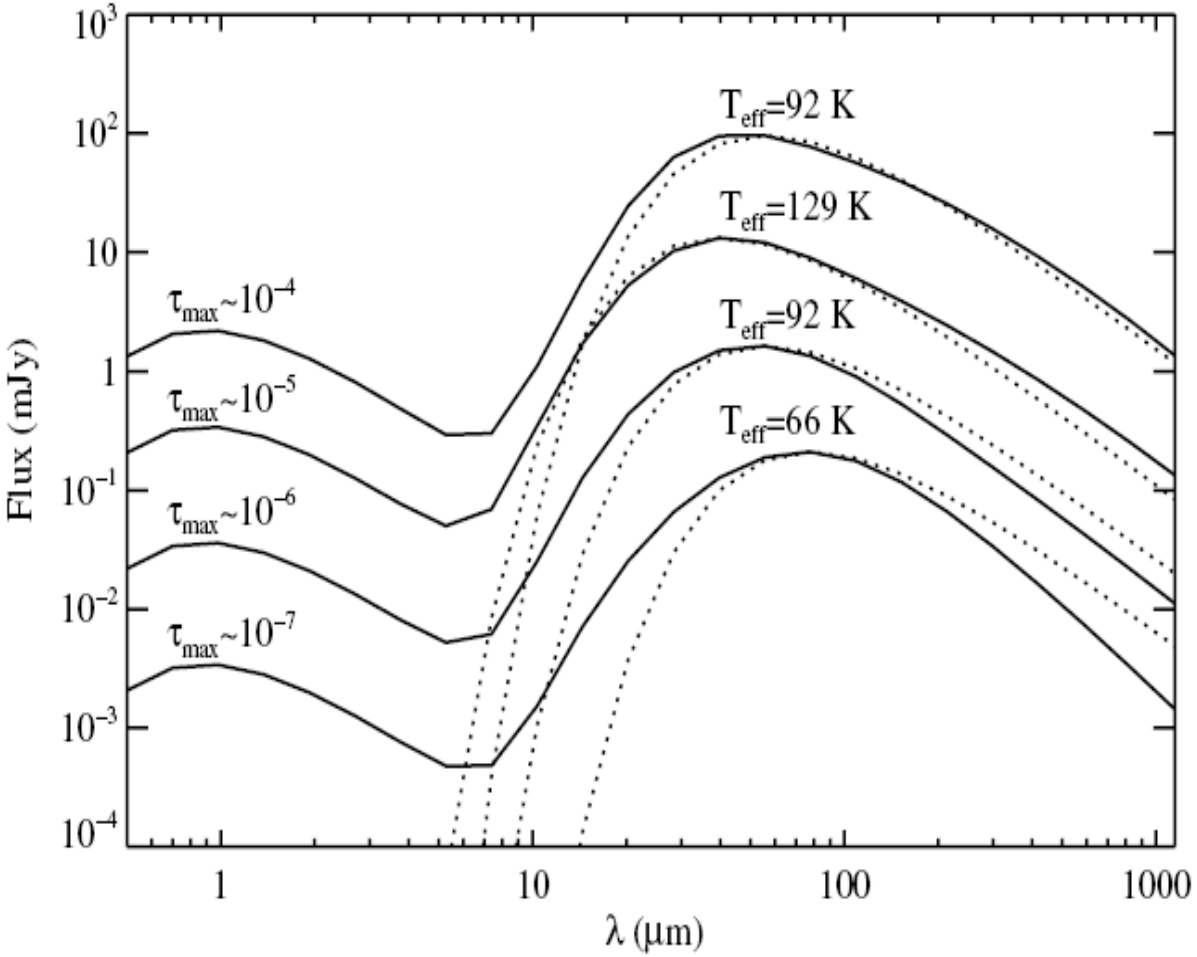
EKB model (Vitense et al., 2013)



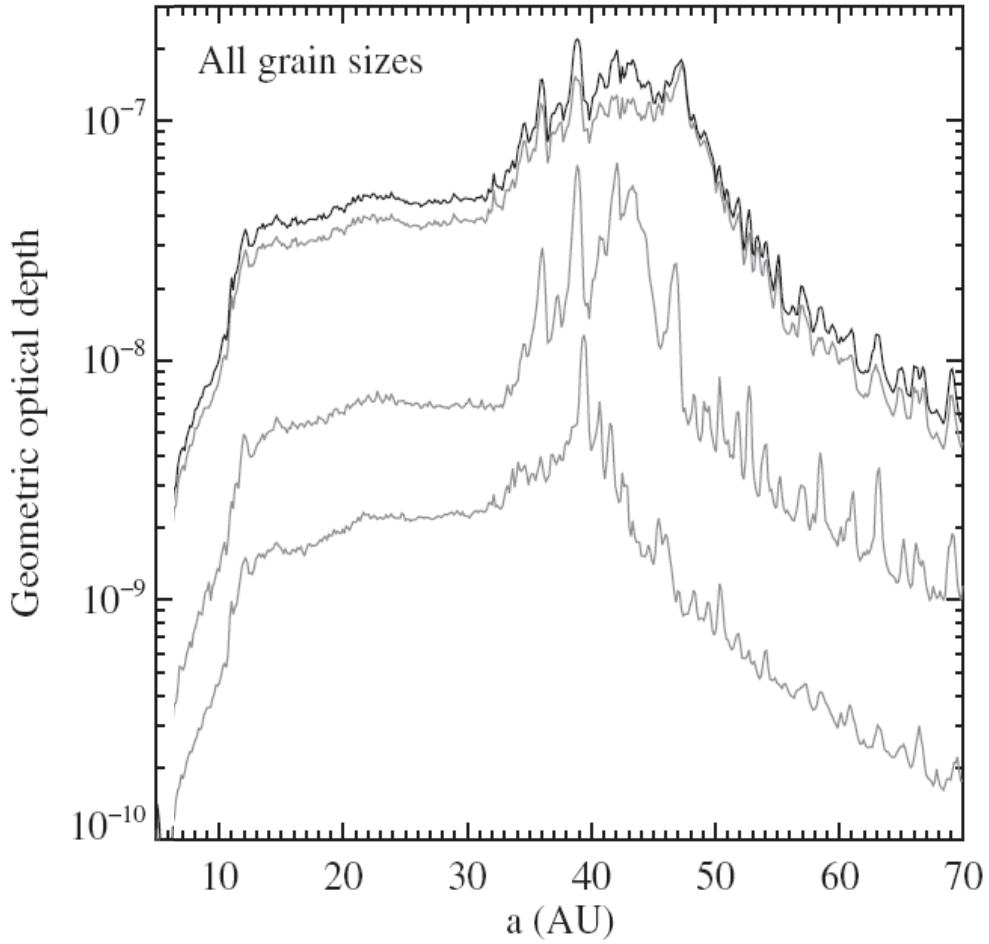
SED model of the EKB including planets and sublimation (solid black line), for the Sun at 10 pc, from Vitense et al. (2012). The peak flux is about 0.45 mJy at a wavelength of about 50 µm. The overall (full disc) luminosity ratio is L(dust)/L(Sun) = 1.2×10^{-7}.

Collisional grooming of the EKB disk (Kuchner & Stark, 2010)



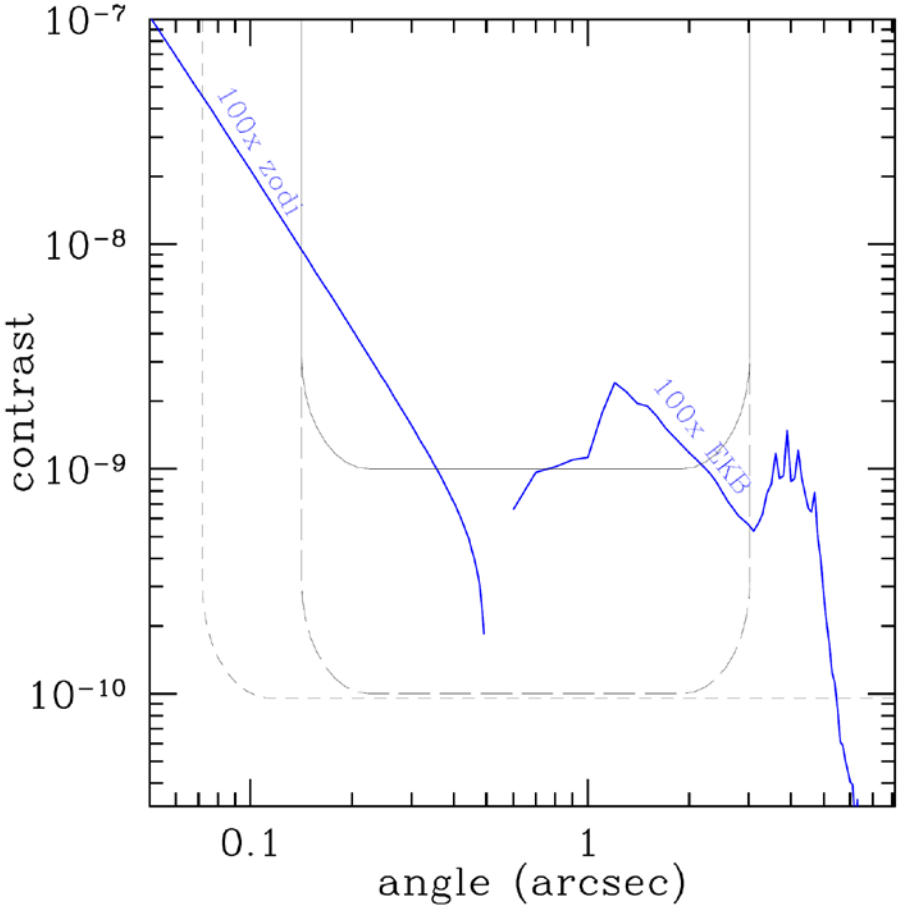
SEDs of 4 EKB dust disc models at 10 pc, including scattered starlight, but not the stellar flux itself, from Kuchner and Stark (2010). Applying the Vitense model of the EKB to this plot, a thermal peak of 0.45 mJy corresponds to an interpolated curve about half-way between the lower two solid curves. The corresponding visible flux is about 0.01 mJy, and the maximum optical depth is about 3×10^{-7}.

EKB optical depth



Radial distribution of geometric optical depth values, from Kuchner and Stark (2010). The light curves are for three types of dust sources in this model, and the top curve is the sum of these. For the present note, I approximated the total depth (top dark curve) by points at 1 AU intervals.

EKB contrast



Apparent contrast (disc/star) of the resolved model EKB, with the brightness multiplied by 100 times, around the Sun at 10 pc distance, in scattered light (0.50 μm wavelength), per resolution element at the focus of a 2.4 m telescope. The inner and outer edges of the EKB are at 5 and 70 AU, corresponding to angles of 0.5 and 7.0 arcsec. This model is based on the Vitense et al (2012) model of the EKB in the thermal infrared, and on the Kuchner and Stark (2010) model which includes scattered light in the visible as well as thermal emission in the far infrared. Some stars have dust luminosities 10^2 to 10^4 times the Sun's, so the curve shown here is 100-times the brightness of the EKB itself.

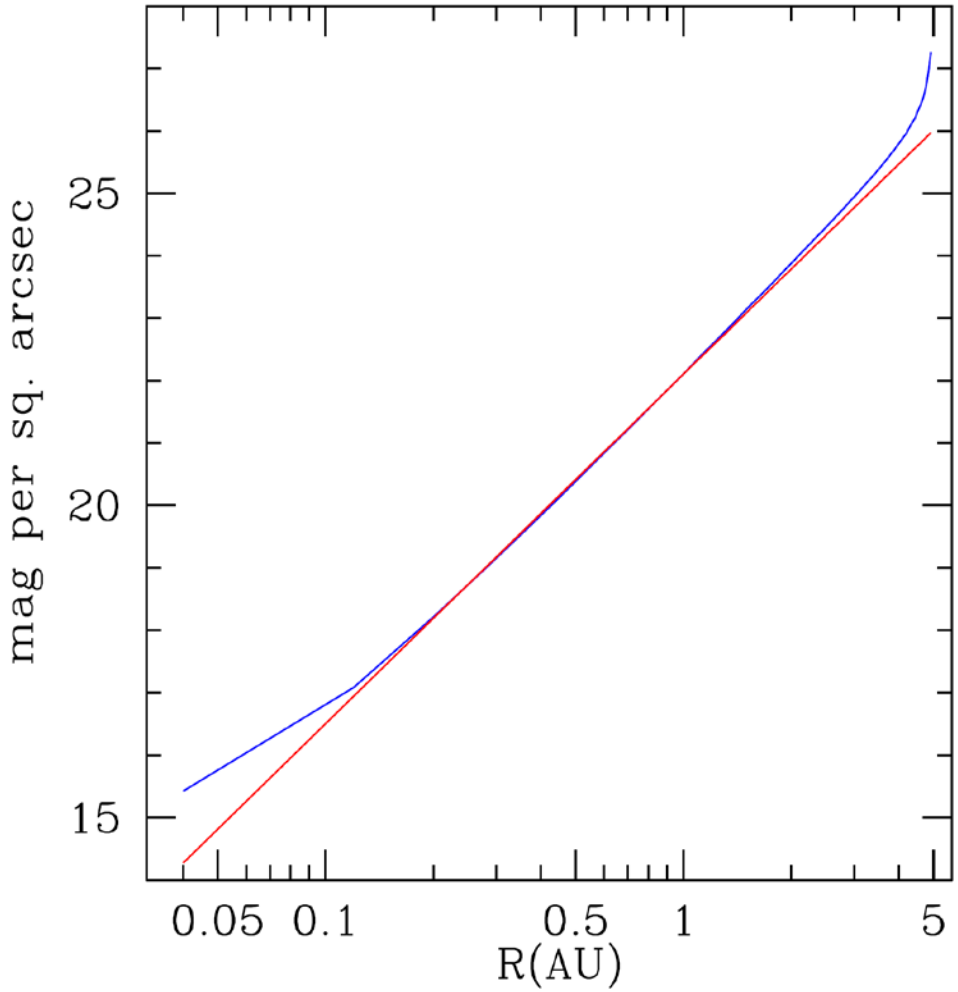
Zodi disk contrast

- Kuchner gives surface brightness of zodi disk (TPF-C, 2006, zodipic)
  - 500 nm, 0.04-4.92 AU, $0.7\times10^{-7}r^{-0.34}$, 1500K, A=0.18, Hong phase fn.
  - $m_V \cong 22.1 + 5.6\log(R_{AU})$ mag/arcsec^2

- Krist gives PSF for AFTA:
  - FWHM(AFTA) = $0.96\lambda/D$ (1.03 for clear aperture)
  - f(FWHM, AFTA) = 0.35 (0.475 for clear aperture)

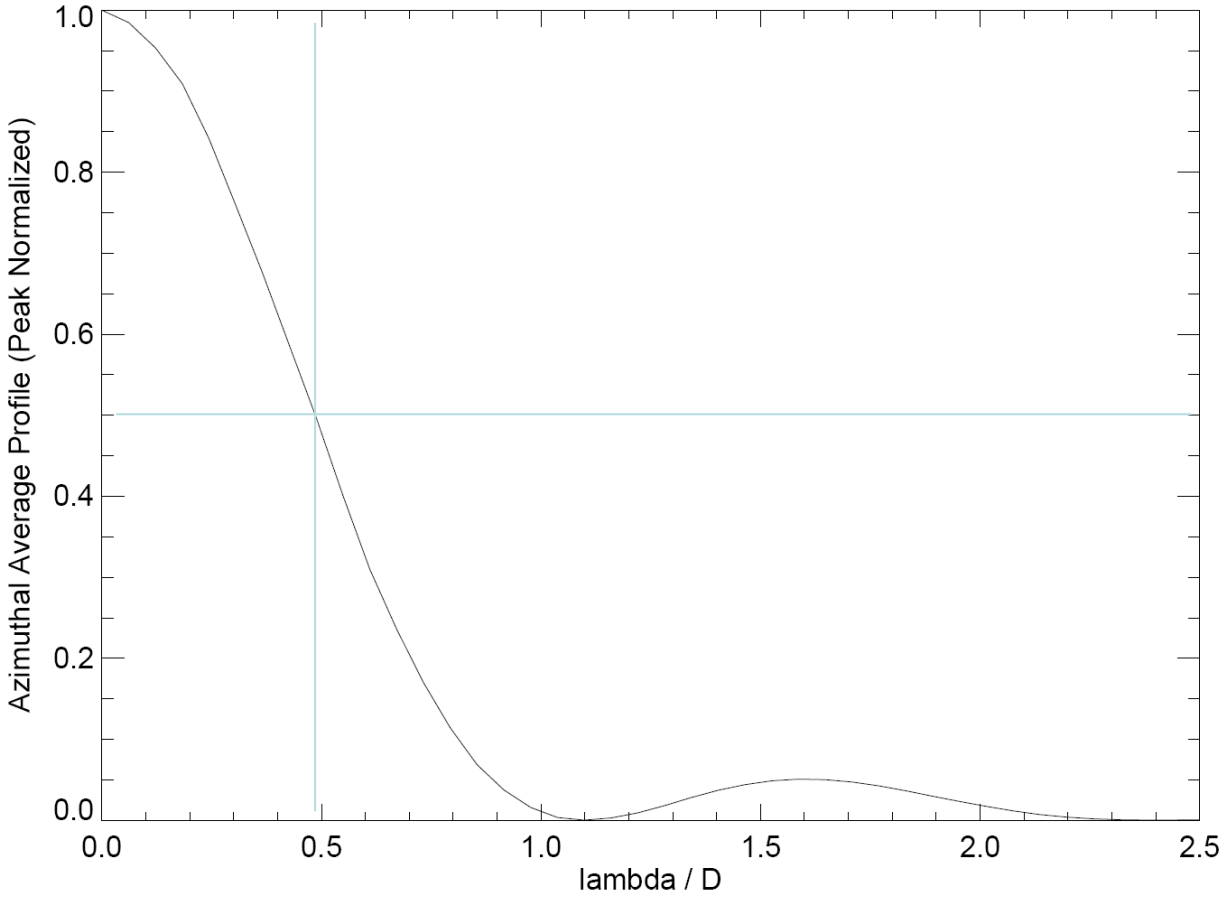
- Contrast calculation:
  - Ω(FWHM, AFTA) = $(\pi/4)$(FWHM)^2
  - Zodi flux in FWHM is $\Omega \times 10^{-4.43-0.4m(zodi)}$ erg/(s cm^2 μm)
  - Star flux in FWHM is $f \times 10^{-4.43-0.4m(star)}$ erg/(s cm^2 μm)
  - Contrast ratio: $C = (\Omega/f) \times 10^{-0.4(m(zodi) - m(star))}$
  - Approximate form: $C \cong 5.67 \times 10^{-10} \times R_{AU}^{-2.24}$

Zodi brightness & fitted model



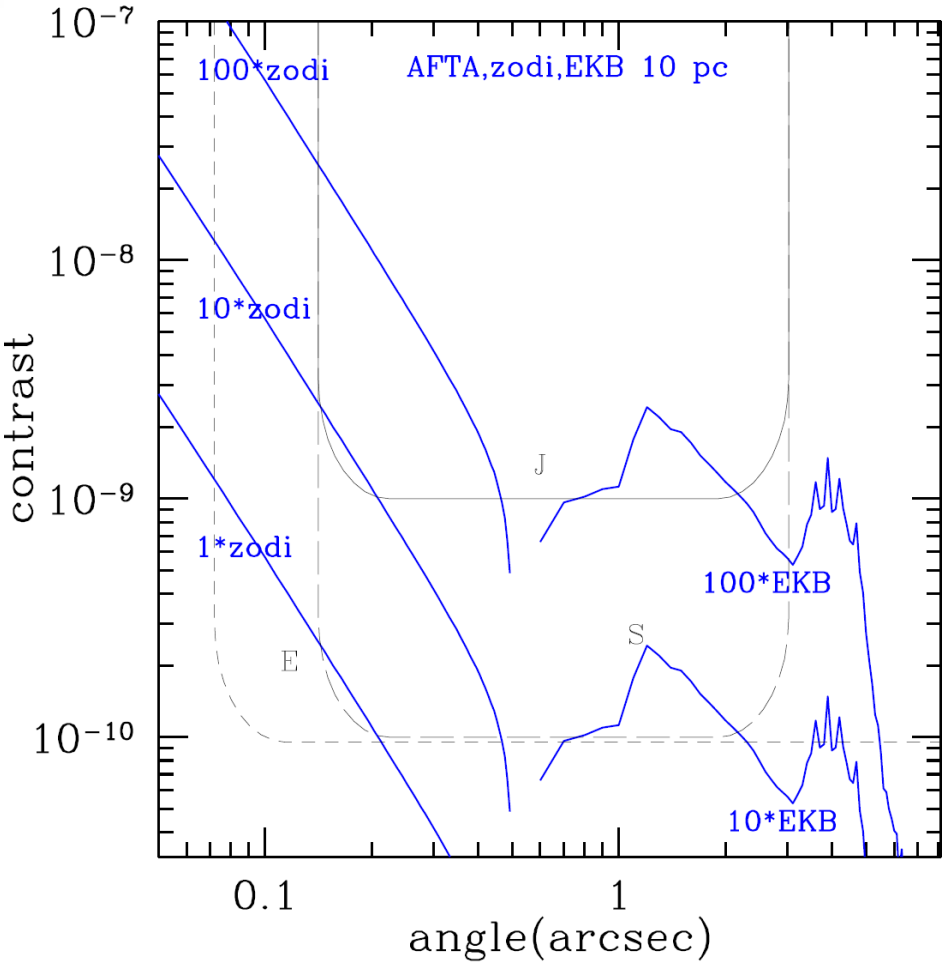
Surface brightness model of the Solar System's zodiacal disc, as seen from a distance, at 60-deg inclination, at visible wavelengths (0.50 μm), (blue line), from Kuchner (2006), along with an analytical approximation (red line).

PSF for AFTA



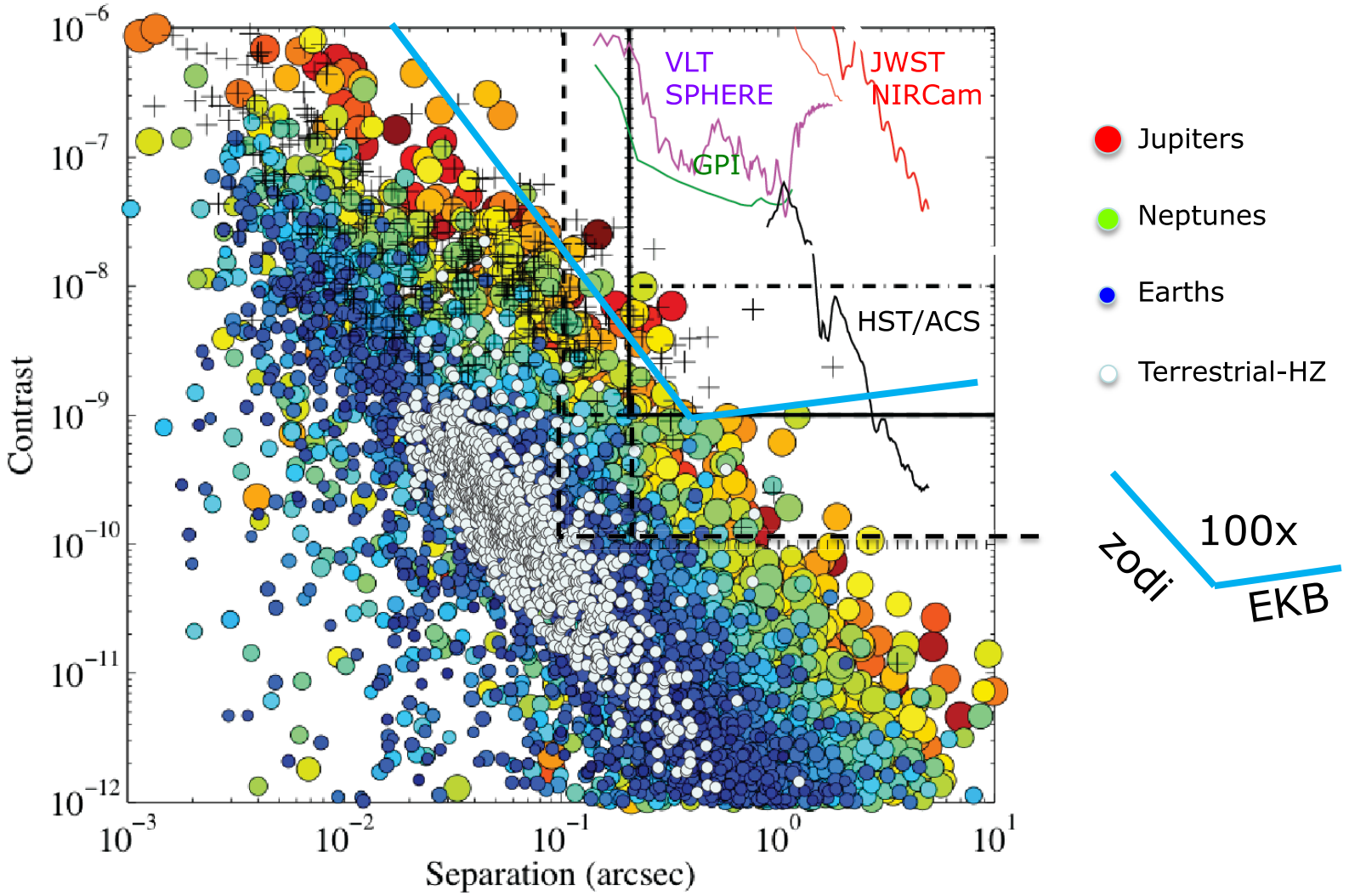
Azimuth-averaged PSF of the centrally-obscured AFTA telescope (Krist, 2013).

Derived zodi contrast



Apparent contrast (disc/star) of the resolved model zodi and EKB disks around the Sun at 10 pc, in scattered light (0.55 μm wavelength), per resolution element at the focus of the 2.4-m AFTA telescope. The inner and outer edges of the zodi are at 0.04 and 4.92 AU, corresponding to angles of 0.004 and 0.492 arcsec. The zodi model is from Kuchner (2006). The EKB curves are models of the Solar System's Edgeworth Kuiper Belt (Traub, 2013).

AFTA modified to show Earths & strong zodi/EKB



Ref.: AFTA Final Report 2013, for 2.4-m, modified by Traub & Lawson