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DOCUMENT

Influence of an exozodiacal dust ring around a target on the observation process of EChO

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1 THE ORIGIN OF THE EXOPLANET EXOZODIACAL DISK AND ITS SIGNATURE IN LIGHTCUVES.

Like our own solar system, which exhibits a circumstellar dust ring, the zodiacal disk, other stars may exhibit disks, which can be either young disks (protoplanetary disks) built during the stellar formation process, and where planets form, or debris disks, around evolved stars, which are the signature of other post planetary formation effects around it, such as small body collisions. Because of the presence of planets, resonances and interactions with the disk may happen, leading to a non uniform distribution of dust within the disk with respect to the orbital distance (Fig 1). As a consequence, the presence of a disk around a star with a transiting planet may lead to specific photometric variations out of the classical transit signature. This question has been extensively studied by Stark (2011). In this technical note, we gather the main elements from this paper in the context of the EChO project.

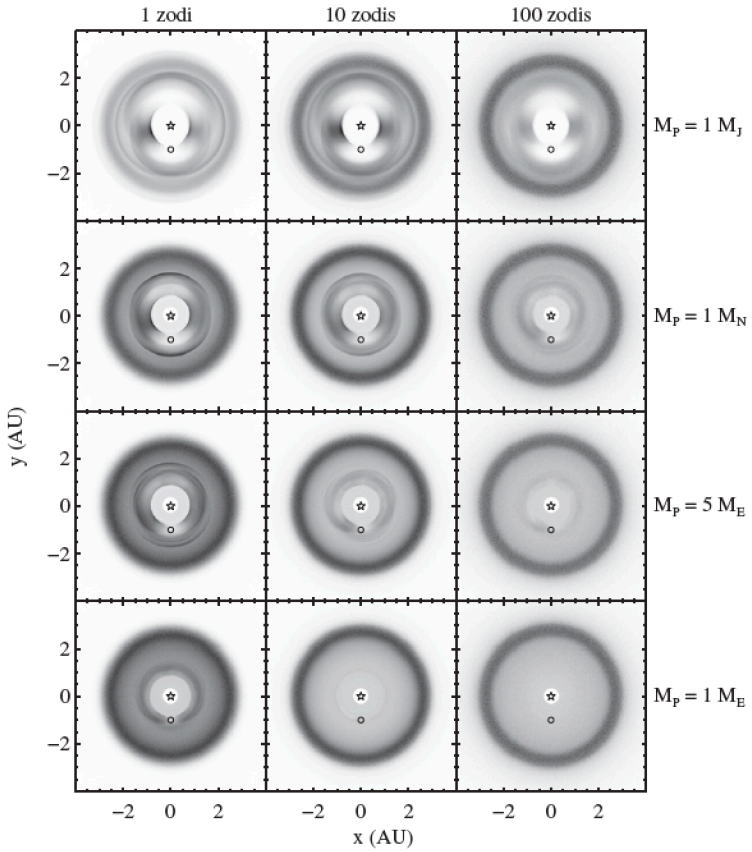

Figure 1 : Optical depth of several dust ring models. The presence of a massive planet around massive disks leads clearly to the formation of dust asymmetry within the disk (from Stark 2011).

In the planetary transit observation geometry, the potential disk is seen edge-on. When a planet orbits within such a disk, at the inner side for short period planets, the classical transit pattern exhibits extra patterns, depending on the observation spectral range. In the visible spectral range, the presence of dust in the line of sight leads to absorption and scattered light, and thus, the pattern may be complex. In the infrared, the presence of the disk affects the transit light curve because the disk absorbs part of the planetary signal (occultation) and is also an extended source of flux. The total light curve is thus the result of a combination of the occulted stellar flux and forward-scattered flux from the disk. Fig 2 shows the extra pattern following a classical transit, in the presence of an exozodi disk, in the visible spectral range.

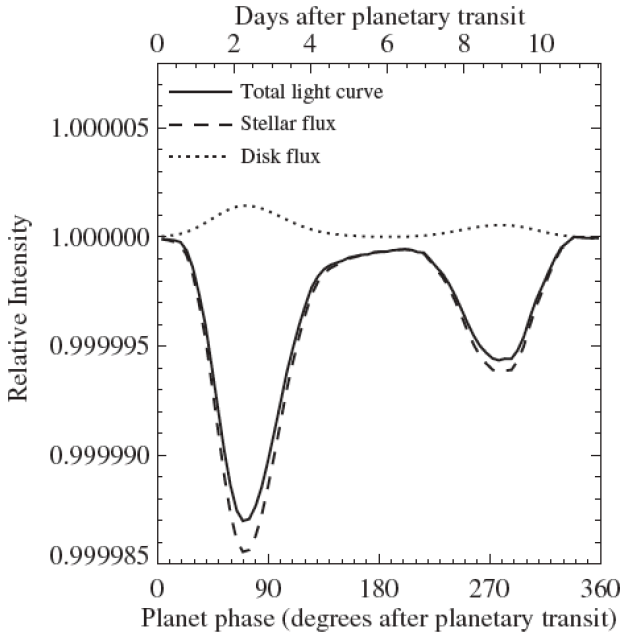

Figure 2 ; extra pattern created by a 10 zodi dust cloud with a $1M_J$ planet at 0.1 A.U on the visible light curve (from Stark 2011).

The amplitude of the phenomenon depends mainly on the intensity of the disk and the mass of the planet that creates the asymmetry within the disk and is represented on fig 3. For planetary masses up to several Earth mass, the effect is negligible at the scale of EChO specifications, whatever the zodi intensity can be (up to 1000 solar zodis). However, for giant planets, the amplitude of the extra pattern can reach 10^{-4} of the stellar signal and is comparable to the chromatic planetary signal that is observed. In the case of giant planet observation, it is thus necessary as much as possible to identify the presence of massive exozodiacal clouds around the target and estimate their intensity.

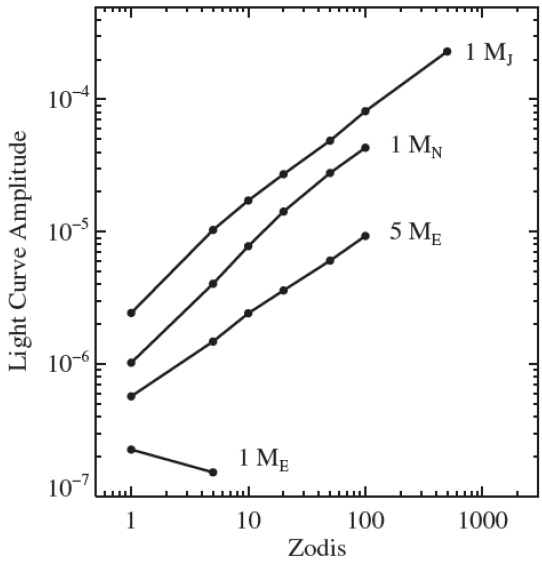

Figure 3 : Amplitude of the extra transit pattern as a function of the disk intensity and the mass of the transiting planet (from Stark 2011).

2 WHAT DO WE KNOW ABOUT EXOZODIACAL CLOUDS AROUND NEARBY STARS ?

The environment of nearby stars is not well known at all, because of the lack of sensitivity of the majority of infrared instrument. Spitzer and WISE show that 1% of star have a disk brighter than 1000 solar zodis, The Keck nuller showed that about 12% of stars have a disk brighter than 150 zodis (Millan-Gabet et al, 2011). This study is however based on several marginal detections (3 for 25 stars). The only real statistical study has been published by Absil et al. (2013) and is based on the observation of a (biased) sample of 42 stars with a spectral type from A to K (12 A-stars, 14 F-stars, 14 G-K stars) and a magnitude in K band up to 4. In this study, the authors measure by near IR interferometry, the radius of stars with an IR excess (of about 1 % of the stellar flux) and try to correlate it with the IR excess in terms of potential dust ring. The results of this analysis is reported on fig.4

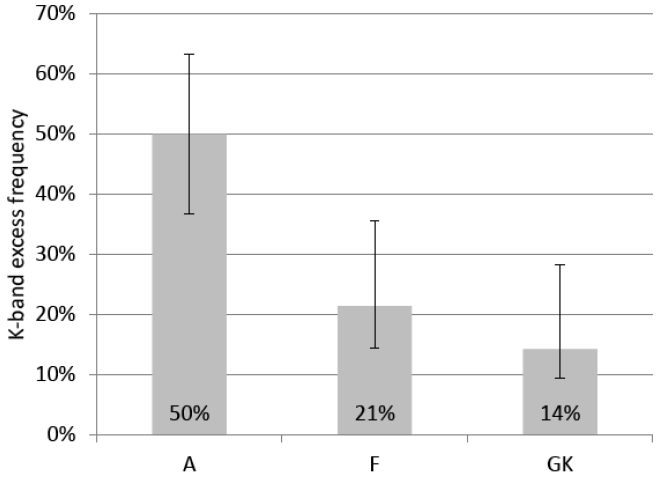

Figure 4 : Statistical distribution of stars with a 1% IR excess, identified as a dust ring. The mean value, whatever the spectral type can be is 27% (from Absil et al. 2013)

This study shows clearly that the presence of a massive dust ring is not a rare phenomenon around evolved stars. The presence of a planet at the inner side of the Fomalhaut debris disk is another illustration of this effect. It thus would be interesting to consider, as preliminary observations and sciences, the characterisation of the stellar environment of EChO targets. Fig 5 show the different facilities that can be considered in that purpose, as a function of their sensitivity.

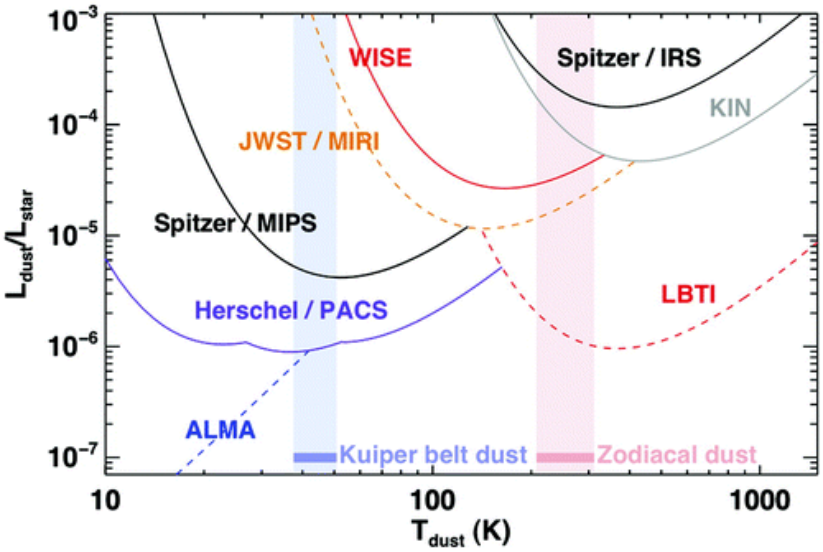

Figure 5 : Potential facilities that can be used for the characterisation of EChO targets environment. Some of them are not available any longer, but are given as sensitivity references (from Roberge et al, 2012) .

3 CONCLUSION

The presence of a dust ring around the EChO does not appear to be a showstopper (at least in the visible / NIR) except if the disk is bright and the planet is massive. In that case, the asymmetry in the disk created by the planet can leads to extra patters in the stellar light curve. In that case, a preliminary careful study of existing light curves is possible to identify the star which are in this situation.

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