Comm. in Asteroseismology
Vol. 152, 2008

β Pictoris: Planets and Pulsations

K. Zwintz[1]

[1] Institut für Astronomie, Türkenschanzstrasse 17, 1180 Vienna, Austria

Abstract

The A5 dwarf star β Pictoris has been subject of numerous studies because it addresses several questions of stellar astrophysics, like stellar evolution, circumstellar disks, planet formation and pulsations.
With $V = 3.86$ mag, it falls within the observable magnitude range of BRITE and is a promising target for this space mission.

Evolutionary stage

One of the open questions is the evolutionary stage of β Pic. Latest age determinations agree to 20$\pm$10 million years (e.g., Barrado y Navascues et al. 1999), but with an upper limit of a factor of 10 more. From its position in the Hertzsprung-Russell (HR) diagram (e.g., Vidal-Madjar et al., 1998) it is right on the zero-age main sequence or slightly before. In other terms, β Pic is either a pre-main sequence (PMS) object or a young main sequence star. The debate about its evolutionary stage is still ongoing, but there are indications for the early main sequence phase: the star shows no emission lines in its spectrum, which would be characteristic for the PMS phase. Also, there is no star forming region nearby from which it could have been recently emerged, and the interstellar medium around β Pic is rather thin (e.g., Vidal-Madjar et al., 1998).

Circumstellar disk

β Pic's massive circumstellar disk was first discovered by IRAS observations in 1983 as a large and unexpected infrared excess which was then called "Vega like phenomenon". A year later Smith & Terrile discovered that the dust disk is seen edge on and that it at least extends to 400 AU around the star. As the lifetime of the dust grains is shorter than the star's age, the grains must form permanently. This can be explained by collisions among large, kilometer-sized bodies like comets or by slow evaporation (Smith & Terrile, 1984).

Vidal-Madjar et al. (1998) report that the disk around β Pic extends up to 1100 AU around the star, i.e., a size of 10 times our solar system. The disk was found to be structured, showing a cleaner, dust-free region at 35 AU from the star. The authors also discovered that the inner part of the disk is slightly warped which can only be explained by at least one giant planet.

Thanks to several, successive Hubble Space Telescope (HST) observations, the most detailed picture yet of a dust disk surrounding a nearby star is available for β Pictoris. These measurements confirmed the slighly warped disk and brought indirect evidence for a large planet orbiting the star within the inner clear zone: The suspected planet itself is too faint to be seen against the bright star, but it is gravitationally sweeping up dust and icy planetesimals from the disk.

Planet(s) around β Pictoris?

One planet at 12 AU with 2 M_{Jupiter} can already explain the observed warp in the disk and 2 of the 4 belt-like structures which were discovered by HST. With two additional planets the other two belts with planetesimals can be explained, where strong upper limits for those planets can be given: one planet should have 2 M_{Saturn} at a distance of 25 AU, the other 4 M_{Neptune} at 44 AU (Freistetter et al., 2007). But no planetary transits have been observed yet.

Pulsations

During the search for a planetary transit around β Pic, δ Scuti like pulsations have been discovered in the star. Koen (2003) identified three frequencies at 47.055, 38.081 & 52.724 d^{-1} with amplitudes below 1.5 mmag using photometric time series in Johnson B filter obtained within 4 nights. Using a 50-cm telescope and a classic PMT still a neutral density filter had to be used to enable the observations of such a bright star.

Spectroscopic time series observations (Koen et al., 2003b) obtained with the GIRAFFE spectrograph at the SAAO 1.9-m telescope clearly show line profile variations. The 18 frequencies inferred from these data were identified to be high-degree, non-radial pulsation modes.

β Pictoris and BRITE

Using the characteristics of BRITE and its detector, 6 unpolluted objects are lying within the field of view of 24° around β Pictoris (see Figure 1). Hence, they could be observed simultaneously.

With the photometry provided by BRITE, the pulsations of β Pic at low amplitudes could be studied in more detail. This is complicated from ground due to the relative brightness of the star. The first detection of a planetary transit lies also within reach of observations with BRITE which would finally provide observational evidence for the theory.

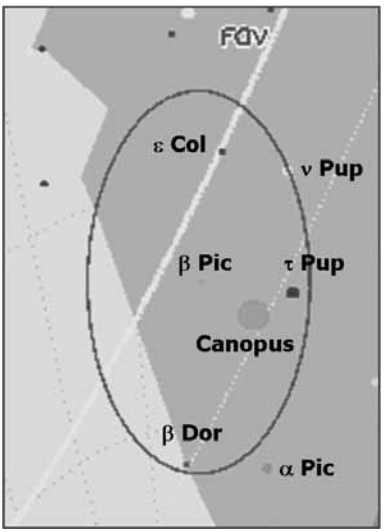

Figure 1: BRITE field of view centered on β Pictoris (Kaiser, priv. comm.).

Acknowledgments. KZ acknowledges funding through the Austrian Science Funds (FWF, project T335-N16).
Use was made of the HST webpage (http://www.stsci.edu).

References

Barrado y Navascués, D., Stauffer, J.R., Song, I., et al. 1999, ApJ, 520, 123

Freistetter, F., Krivov, A.V., Lhne, T. 2007, A&A 466, 389

Guenther, D.B., Kallinger, T., Zwintz, K., et al. 2007, ApJ, in press

The Hipparcos and Tycho Catalogues, ESA 1997, ESA SP-1200

Koen, C. 2003a, MNRAS, 341, 1385

Koen, C., Balona, L.A., Khadaroo, K., et al. 2003b, MNRAS 344, 1250

Smith, B.A., Terrile, R.J., 1984, Science, 226, 1421

Vidal-Madjar, A., Lecavelier des Etangs, A., Ferlet, R. 1998, P&SS, 46, 629