

bRing: The Search for Circumplanetary Material around the young, Gas Giant Exoplanet β Pictoris b

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Abstract

The bRing experiment (" β Pic b Ring") consists of twin two-camera instruments, which will monitor the bright star β Pictoris throughout 2017 and 2018 for signs of obscuration from circumplanetary dust associated with the young gas giant exoplanet β Pic b. bRing will also act as a survey of the brightest stars ($m_v \sim 4-8$ mag) in the southern sky. The instruments will be part of an international campaign to monitor the β Pic system in 2017-2018. The 2017-2018 β Pic transit season represents the first time that an imaged extrasolar planet will be monitored coming close to passing in front of its star. It will be the best opportunity yet for observational constraints on the late stages of gas giant planet formation and the nature of circumplanetary disks, which may spawn exomoons [1]. The formation and evolution of exomoons is of astrobiological interest as they may be a common type of habitable world [2].

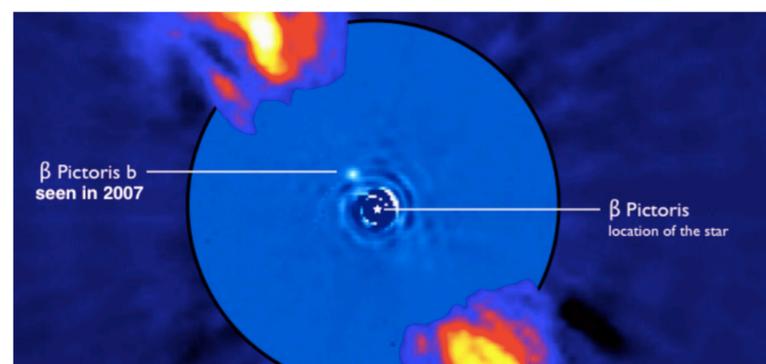
Motivation

Theorists have long predicted that the gas giant planets in our own solar system must have circumplanetary disks of dust (and gas) early in their history in order to explain the existence and properties of the large, regular satellites (e.g. Galilean satellites around Jupiter) [1]. Such moon-forming disks have predicted sizes, optical depths, and frequencies of occurrences, which should make detectable astronomically via transits [3]. The opportunity to observe such active disks would provide a glimpse into the processes that lead to the development icy satellites, which could host abodes of extraterrestrial life within their tidally heated subsurface oceans [2,4,5]. Such a disk around J1407b has already been discovered, hinting there may be more around similar systems [3].

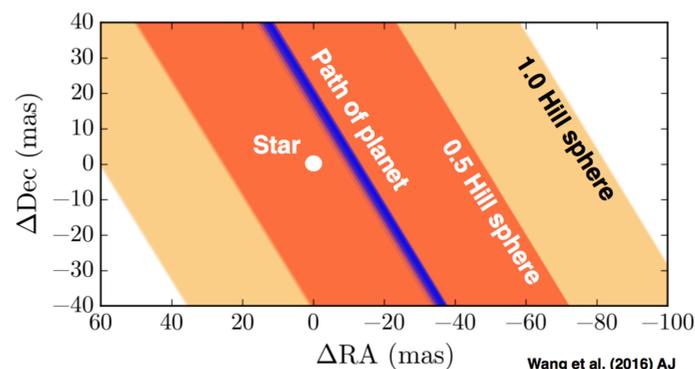
The impending (2017-2018) Hill sphere transit of the young giant planet β Pic b provides the best available candidate for characterizing moon-forming circumplanetary disks [6,7]. We present bRing, an experiment designed to continuously monitor the impending Hill sphere transit of β Pic b. It is reasonable to suspect that β Pic b may host circumplanetary material within its Hill sphere (<1.2 AU). The system is very young (~ 23 million years) and the star β Pic famously has a very dense circumstellar dusty debris disk. It is possible that rapid photometric variations of Beta Pic observed in 1981 - long before the discovery of either the exoplanet or the debris disk - may have been due to material associated with the exoplanet [8].

β Pictoris

(1) Epoch 2007 image of β Pictoris with β Pictoris b superimposed on a continuum image of the circumstellar disk. An extended ring system (if viewed at the right angle) would eclipse the star. (Image credit ESO/A.-M. Lagrange et. al)



(2) An illustration of the area on the sky swept out by the β Pic b Hill Sphere during closest approach (Figure 6 of [7]). The size of the Hill radius is ~ 60 mas (1.2 AU) and the closest approach to the planet will be ~ 10 mas. (Figure courtesy of Kenworthy)



Technical Information

The robotic observatory was designed by Remko Stuik and is based off of the successful five-camera MASCARA system (sited at La Palma and La Silla) [9,10]. The bRing box contains computers which will process the data from the cameras and transmit processed photometric data back to Rochester and Leiden. The Rochester instrument (bRing-AU) will be sited on a concrete platform adjacent to the ANU 16-inch telescope at Siding Springs Observatory. The Leiden instrument (bRing-SA) is currently sited at the South African Astronomical Observatory in Sutherland, South Africa.

bRing-AU Specifications [11]

- Atik 11000M Cameras
- Kodak KAI 11002 CCD w/ 37.25 x 25.70 mm chip, 4008 x 2672 pixels at 9 μ m, QE of 50%
- Fitted with Canon 24mm f/1.4 wide-field lenses
- Cameras are angled at 45 degrees and are pointed at azimuths 150 and 210
- FOV are 84 x 53 degrees oriented to cover the declination of β Pic down to 3 airmasses
- Alternates between 6.38s and 2.54s exposures with a 1.55s camera read-out time, with <2 pixel drift.
- 0.75m x 0.75m x 1.15m in volume consume roughly 1 kW of energy
- Photometric precision will be at approximately 0.5% over 5 minutes.

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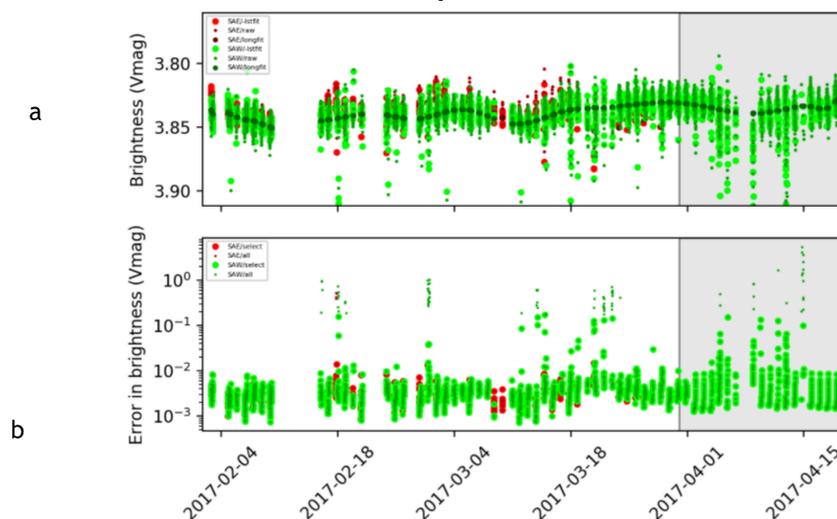
Acknowledgements

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bRing



β Pictoris



Pictured:

- (a) bRing-SA in Sutherland, SA
- (b) bRing-AU South side with detached hood
- (c) bRing-AU North side and Door.
- (d) bRing-SA light curve of β Pictoris