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The Nature of the Dust Disc Surrounding BD+31°643

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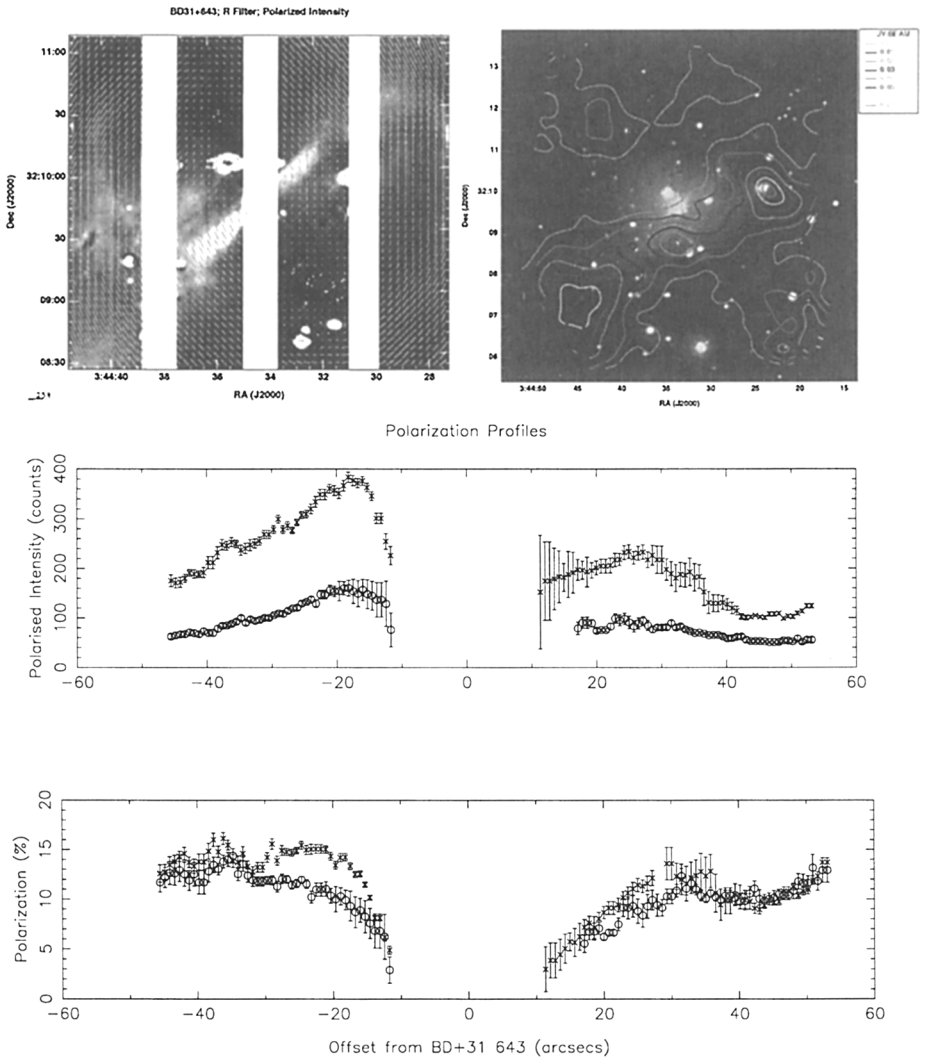
Abstract. Multicolour imaging polarimetry of the main sequence star BD+31°643 shows that the Kalas & Jewitt (1997) disc extends to at least 13000AU. A disc of this radius must be dynamically very young compared to the central star, unlike the situation found in the β Pictoris system. A striking linear filament of 850μm emission detected 50″ south, that parallels the dust disk, is probably not physically associated.

1. Introduction

BD+31°643 is a close B5V binary with a projected separation of 0.6″ (156AU at 260pc). It lies near the centre of the young cluster IC348, which is in turn associated with the Perseus OB2 molecular cloud complex. Coronagraphic images of BD+31°643 taken by Kalas & Jewitt[KJ](1997) unmask circumstellar nebulosity, which they identify as a candidate large, massive orbital dust disc (confirmed by Andersson & Wannier 1997). They detect the disc out to a radius of 20″ (5200AU) and suggest that the inner 7″ is depleted of scattering material, with the dust density following a power law ($r^{-0.7}$) elsewhere. KJ suggest that the inner depletion of dust may be due to radiation pressure on small grains.



Top-left: Figure 1. An R-band linear polarization map (vectors) superimposed on a grey scale polarized intensity image. The bar at the lower left represents 25% polarization. Note how the disk structure is revealed in polarized light with the SE lobe being brighter than the NW lobe. IC 348 is seen to be a reflection nebula with BD+31°643 as the main illuminator.
Top-right: Figure 2. Contours of 850um emission obtained with SCUBA in a 7x7 arcmin field centred on BD+31°643 superimposed on an optical DSS image.
Bottom: Figure 3. Polarization profiles along the disk. The polarized intensity is shown in the upper panel and the percentage polarization in the lower panel, with circles for the B filter and crosses for the R filter measurements

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2. Imaging Polarimetry using the Durham Polarimeter

Polarimetry data taken on the McDonald 1.9m telescope in BVRI (Figs 1&3), show that the KJ disc is seen in polarized light well beyond 20″, in fact out to at least 50″ (13000AU). The percentage polarization rises rapidly from about 5% at 10″ to values between 10 and 16% in the region beyond 20″ from the star. Significant asymmetry is seen in polarized light with the SE lobe being brighter by about a factor of 2 at the peak; the asymmetry is less pronounced in percentage polarization. The brighter SE lobe has roughly constant polarisation beyond 20″ with average values of about 14.5% in R and 12.5% in B.

3. Comparison with the β Pictoris Disc

The scale and age of the disc orbiting BD+31°643 are very different from those of β Pic. Since BD+31°643 is $<$ 7Myr old, according to KJ, and particles at the edge of the disc will orbit in 0.44Myr, it is dynamically very young. The same figures for β Pic are $>$ 10Myr and 27000yr, so the β Pic disc is much more evolved. Polarization results for β Pic (Gledhill et al. 1991, Wolstencroft et al. 1995), can also be compared to those for BD+31°643. The percentage polarization differs side-to-side for each disc by a few percent and the levels are similar in magnitude (β Pic:13% to 20%; BD+31°643:10% to 16% beyond 20″).

4. JCMT SCUBA Observations of BD+31°643 at 850μm

Our 7x7′ field (Fig 2) shows a quasi-linear (5.4′, 84000AU) ridge of 850-micron emission that parallels the optical disc, suggesting that it may be associated with BD+31°643. However, two observations make this unlikely; namely the 50″ N-S offset and the long, implied, orbital period of 7Myr (comparable to the age of BD+31°643). Our preferred explanation is that this offset feature is analogous to the 1300μm, 100000AU linear filament found by Chini et al. (1997) in OMC2 and OMC3 (see also NGC 6334I - Sandell 2000). OMC3 contains a number of 'embedded condensations' which are thought to be class-0 protostars. SCUBA observations by Qualtrough et al. (2000) reveal substantial structure in the emission immediately south of BD+31°643, adding weight to this hypothesis.

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