EPSC Abstracts
Vol. 6, EPSC-DPS2011-1069, 2011
EPSC-DPS Joint Meeting 2011

High-sensitivity search for clumps in the Vega Kuiper-belt

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Abstract

We present new observations of the Vega system with the Plateau de Bure Interferometer. The debris disc around the prototypic Vega is known to extend up to > 800 AU, with a very smooth far IR emission, and possible clumpiness at sub-mm wavelengths. Our observations of a three-field mosaic at 1.3 mm have a factor of two higher sensitivity than previous works. The stellar photosphere is detected with the expected flux, but we find no evidence for the previously reported dust emission peaks that should have been detected at the $> 6\sigma$ level. We derive upper limits for the dust continuum emission that are compatible with observations at shorter wavelengths. All angularly resolved observations indicate that the disc emission around Vega is smooth and circularly symmetric, hence do not require the gravitational influence of a giant planet to sculpt asymmetries, at the current level of detection.

1. Introduction

The face-on disc around the emblematic Vega star has been imaged from IR to mm- wavelengths. Its appearance curiously seems to change from a smooth azimuthal profile at short wavelengths to a more structured, clumpy ring in the sub-mm domain. The thermal emission profile suggests a ring-like distribution of grains, with a peak intensity around 85 AU [7, 5, 4]. Possible brightness asymmetries have been reported in the sub-mm domain [3, 2, 5], although with a weak statistical significance. The presence of two emission blobs was claimed by [1] from PdBI observations at 1.3 mm. While not present in the original resolution map, a northeast and a southwest peaks were reported in the degraded resolution map, close to the radial distance of the dust ring. These possible concentrations of extended emission have suggested the presence of gravitationally trapped grains, in mean-motion resonance with an unseen giant planet [3, 1, 8].

2. Observations

In the framework of the science verification program, Vega was observed in January and November 2007 at 230.5 GHz at PdBI, in a compact array configuration well suited for detecting large scale emission. The final three-field mosaic optimises the signal-to-noise ratio at the location of the putative blobs. With a total observing time of 16h on source, we finally reached a sensitivity limit below 0.2 mJy/beam (0.9 mK) in the central region of the mosaic, and < 0.4 mJy/beam within 11" (or 85 AU) from Vega .

3. Results

We detected only a point-source emission in each of the fields (Fig. 1). Its fitted position and its flux density (1.95 ± 0.17 mJy) agree well with those expected for the stellar photosphere as well as with [1]. We found no evidence for the two blobs claimed by [1]. With expected fluxes of 7.1 ± 1.4 and 4.3 ± 1.0 mJy, they should have been detected at the 10-15σ (resp., 6-10σ) level in our untapered (resp. tapered) map.

4. Discussion

Our observations are consistent with no detectable mm emission from the outer disc around Vega. To set an upper limit on the 1.3 mm emission of the ring, we fitted a uniform, 85 AU radius ring into the *(u,v)* data and derived a 3σ upper limit of 6 mJy that corresponds to a maximum dust grain mass of about 0.8 $M_{\rm moon}$. This value is consistent with the maximum value obtained by [6] in their modelling of the Vega disc as a steady-state collisional cascade. If we assume a grain distribution following the geometrical model proposed by [4], we can set 3σ upper limits of 24 mJy within 200 AU and 30 mJy within 300 AU. These fluxes agree also well with the 12 mJy value extrapolated from the (fitted) dust spectral index ($\beta = 2.9$) derived from the sub-mm measurements of [3] and [4].

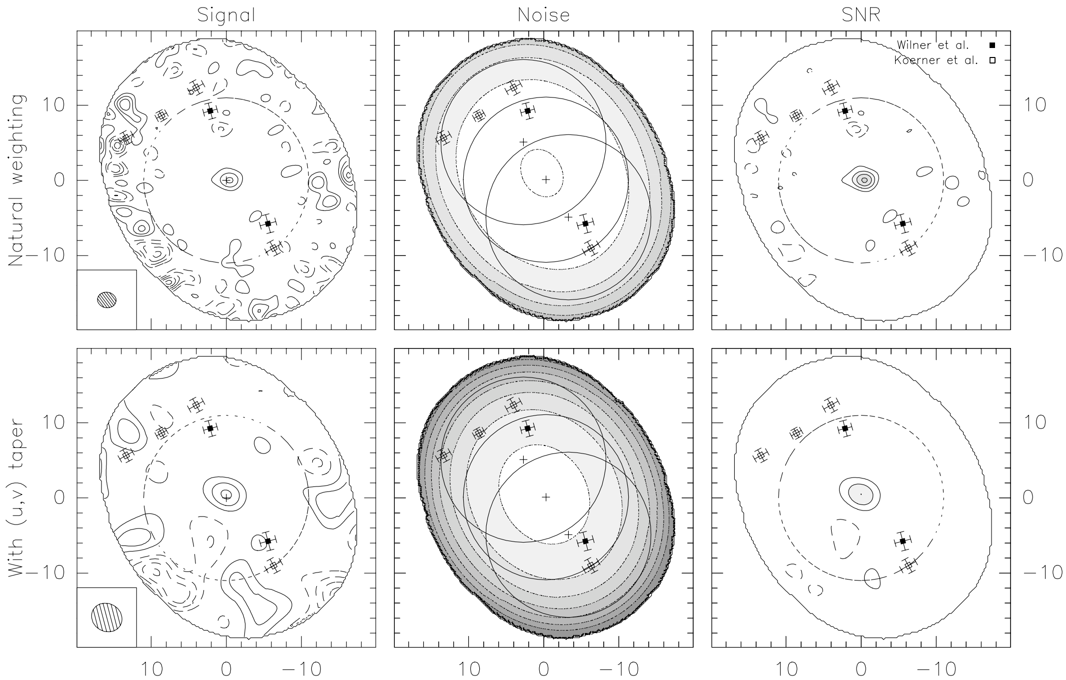

Figure 1: **Top left:** natural weighting 1.3 mm continuum image (corrected for the primary beam attenuation). The angular resoluion is 2.5×2.1" at PA 82° and the contour spacing 0.5 mJy/beam (2.1 mK), with negative contours being dashed. The dashed circle represents the primary-beam half-power field of view. **Top center:** corresponding noise map. Contour spacing is 0.2 mJy/beam . The circles show the observed individual fields (half-power field of view, centered on the crosses). **Top right:** signal-to-noise ratio map. Contour spacing is $2\,\sigma$. **Bottom left:** 1.3 mm continuum image obtained with a (u, v) taper. Angular resolution is 4.2×3.7" at PA 60° and contour spacing is 0.6 mJy/beam (0.8 mK). **Bottom center:** corresponding noise map. Contour spacing is 0.2 mJy/beam (with the first contour being at 0.4 mJy/beam). **Bottom right:** signal-to-noise ratio map. Contour spacing is $2\,\sigma$. In all maps, the filled square symbols indicate the location of the extended emissions found by [1] and the empty square symbols indicate the location of the peaks reported by [2]. North is up, and east to the left.

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