DISK KINEMATICS AND TIDAL STRIPPING IN THE RW AUR SYSTEM. S. Cabrit, *LERMA, UMR 8112, Observatoire de Paris, 75014 Paris, France (sylvie.cabrit@obspm.fr)*, J. Pety, *Institut de Radioastronomie Millimetrique, 38406 Grenoble cedex, France*, N. Pesenti, C. Dougados, *Laboratoire d'Astrophysique, UMR 5571, Observatoire de Grenoble, France*.

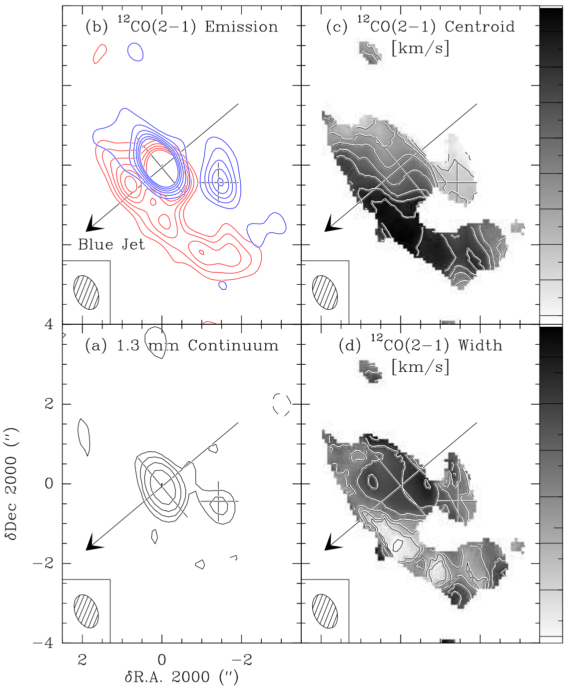

Figure 1: **(a)** 1.3 mm continuum map of the RW Aur system. Crosses indicate the positions of RW Aur A and B. The arrow shows the direction of the blueshifted jet from RW Aur A. **(b)** ^{12}CO J=2–1 emission, blueshifted (blue/dark contours) and redshifted (red/grey contours) with respect to the RW Aur A systemic velocity $V_{\rm helio} \simeq$ 15.7 $\rm km\,s^{-1}$. Contour spacing is 3σ (0.12 Jy $\rm km\,s^{-1}$), truncated to 18σ. **(c)** Line centroid velocity (heliocentric). **(d)** Line width. Beam size is $0.89'' \times 0.58''$ at PA = 23°.

Abstract: We present interferometric maps of the RW Aur system, obtained with the IRAM Plateau de Bure Interferometer[1] in ^{12}CO(J=2–1), ^{12}CO(J=1–0), and nearby continuum. The sub-arcsecond angular resolution ($0.89'' \times 0.58''$) and high-sensitivity reached at 1.3mm allows us to resolve three molecular structures: (1) a compact and warm rotating disk around RW Aur A, (2) a disturbed disk around RW Aur B, and (3) an unusual redshifted "arm" that appears to be tidally stripped from the primary disk and possibly feeding the secondary. The RW Aur A disk rotates in opposite sense to the tentative rotation signatures found in the optical jet by [1]. Implications of our results on the jet launching region and on the origin of enhanced accretion in this system are briefly outlined. More details can be found in Cabrit et al. (2005, submitted).

[1]IRAM is supported by CNRS (France), MPG (Germany), and IGN (Spain).

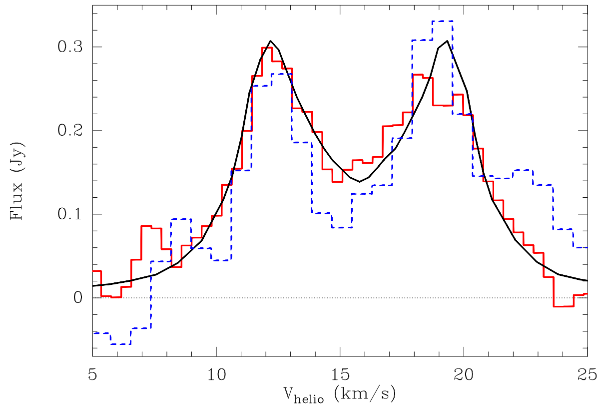

Figure 2: Continuum subtracted ^{12}CO spectra towards RW Aur A. Solid histogram: ^{12}CO J=2–1. Dashed histogram: ^{12}CO J=1–0, multiplied by 4. Solid curve: theoretical profile from [2] for a keplerian disk viewed at 45°, appropriately scaled to an outer radius $42(M_\star/1.4\,M_\odot)$ AU and outer gas temperature $120(M_\star/1.4\,M_\odot)^{-4/3}$ K.

1. ^{12}CO results

1.1 The RW Aur A rotating molecular disk

We find a compact, bright CO structure centered on RW Aur A (**Fig. 1b**), displaying several characteristics typical of a rotating keplerian disk: (i) A velocity gradient exactly perpendicular to the RW Aur A jet axis (**Fig. 1c**); (ii) An optically thick, double-peaked CO line profile (**Fig. 2**) in excellent agreement with the calculated profile for a keplerian disk viewed at the same inclination $i \simeq 45°$as the RW Aur A jet [2,3]; (iii) A spatial offset of the red and blue emission peaks compatible with keplerian rotation around RW Aur A (**Fig. 3**).

The disk rotation sense is opposite to that found in the jet by [1], *i.e.* the disk rotates clockwise, looking from the tip of the blue lobe down to the star (**Fig. 3, top**).

Comparing the CO line profile shape and intensity with the modelling results of [2], we infer the following disk properties:
- A small disk radius $R_{\rm out} \simeq 40$ AU, consistent with the detection of the redshifted jet lobe down to $0.2''$ from the star [4].
- A rather high gas temperature $T_{CO} \simeq$ 120K, presumably tracing a "superheated" surface layer of the disk [5,6].

2.2 The red-shifted molecular arm: a tidal tail ?

The CO map reveals a large reshifted "arm" wrapping around RW Aur A, with low-level blueshifted emission connecting it to RW Aur A, and possibly to RW Aur B (**Fig. 1b**). The kinematic pattern (**Fig. 1c**) is not compatible with rotation, and rather favors expansion motions: (1) the maximum redshift in the arm exceeds the free-fall speed towards RW Aur

A and RW Aur B, hence the arm is at least partly unbound; (2) assuming the arm lies roughly in the same plane as the RW Aur A disk (as expected from angular momentum considerations), the position of the blue jet implies that the redshifted arm lies on the *far side* of the disk. Hence it would be expanding away from RW Aur A.

Based on the morphology and kinematics, we propose that the expanding arm ais a tidal tail resulting from stripping of the RW Aur A disk by its companion. Indeed, numerical simulations of disk perturbation in an excentric binary system show tidal arms with a morphology reminiscent of that observed here [7]. More detailed modelling is under way (Reche et al., in preparation).

2.3 The RW Aur B molecular peak: a disturbed disk

A fainter, slightly resolved CO peak is seen towards RW Aur B, with a mean blue-shift of $\simeq -3\ \mathrm{km\,s^{-1}}$with respect to RW Aur A (**Fig. 1b,c**). It is difficult to identify an unambiguous disk signature in the data. Up to three velocity components are seen, indicating strong deviations from a rotating pattern. Tidal interaction and capture of material from the RW Aur A disk could be responsible for these.

3. Main implications

- The rotation sense of the RW Aur A CO disk indicates that transverse velocity shifts measured in the optical jet by [1] are dominated by other effects than rotation (*e.g.*internal oblique shocks, non-axisymmetric instabilities). The inferred jet launch radii of $0.4 - 1.6$ AU are then upper limits only. Increased spectral and spatial resolution is needed to definitely test MHD disk wind models in this jet.

- The strong tidal disk interaction we are witnessing may explain how RW Aur A can sustain a high accretion rate ($\simeq 2 - 10 \times 10^{-7}\,\mathrm{M_\odot\,yr^{-1}}$ [8,9]) despite a small disk mass [10] and the lack of a nearby cloud. Dissipation associated with tidal stripping is expected to trigger a transient accretion outburst onto the stars [7]. Then, the current accretion rate in RW Aur A would not be representative of its mean level, and the disk lifetime would be longer than previously thought.

Acknowledgements: This research is supported by the JETSET Marie Curie Research and Training Network, as part of the European Community's Human Potential Programme, under contract MRTN-CT-2004-005592.

References: [1] Woitas, J., et al. 2005, A&A, 432, 149; [2] Beckwith, S. V. W., Sargent, A. I. 1993, ApJ, 402, 280; [3] López-Martín, L., Cabrit, S., Dougados, C. 2003, A&A, 405, L1; [4] Woitas, J., et al. 2002, ApJ, 580, 336; [5] Chiang, E. I., Goldreich, P. 1997, ApJ, 490, 368; [6] Glassgold, A. E.,Najita, J., Igea, J. 2004, ApJ, 615, 972; [7] Bonnell, I., Bastien, P. 1992, ApJL, 401, L31; [8] Basri, G. & Bertout, C. 1989, ApJ, 341, 340; [9] Hartigan, P., Edwards, S., & Ghandour, L. 1995, ApJ, 452, 736; [10] Osterloh, M. and Beckwith, S. V. W. 1995,ApJ,439, 288

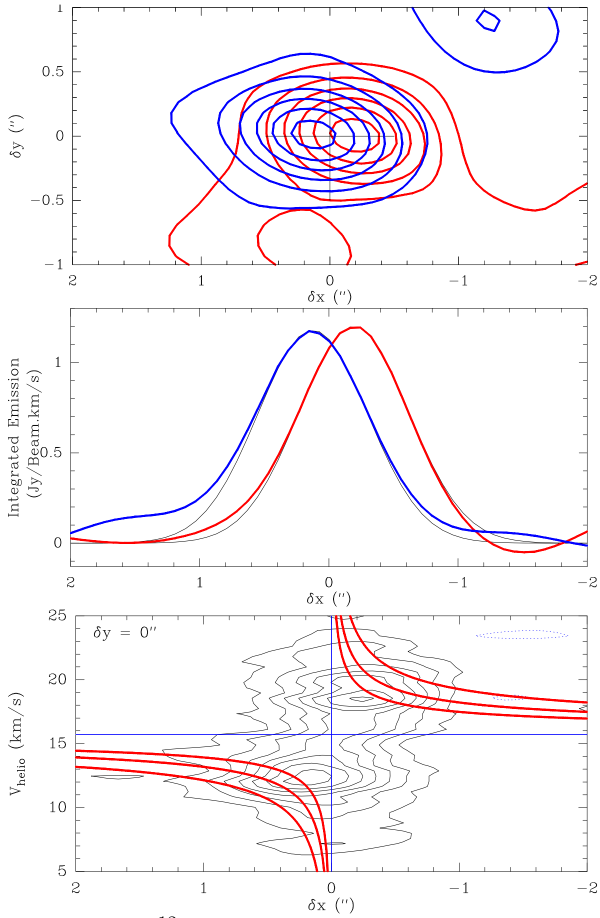

Figure 3: **Top:** ^{12}CO J=2–1 integrated emission map towards RW Aur A, rotated so that the blue jet points in the *-y* direction. Dark contours: blueshifted emission. Grey contours: redshifted emission. The blue/red shift is in opposite sense to that found in the jet by [1]. **Middle:** Intensity cuts along the x–axis, and gaussian fits. The peaks are at $\delta x = 0.125''$ (blue) and $\delta x = -0.195''$ (red). Note the high signal-to-noise of the data. **Bottom:** Position–velocity diagram along the x axis. Angular resolution is 0.8". Horizontal and vertical lines indicate the systemic velocity and position of RW Aur A. Thick curves plot the Keplerian velocity around a central star with $M_\star \times \sin i = 0.5, 1$ and $2\,\mathrm{M_\odot}$. The middle curve corresponds to the RW Aur A parameters ($M_\star \simeq 1.4 \pm 0.1\,M_\odot$, $i \simeq 46° \pm 3°$).