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HD141569A: Disk Dissipation Caught in Action

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Abstract. Debris disks are usually thought to be gas-poor, the gas being dissipated by accretion or evaporation during the protoplanetary phase. HD141569A is a 5 Myr old star harboring a famous debris disk, with multiple rings and spiral features. I present here the first PdBI maps of the ^{12}CO(2-1), ^{13}CO(2-1) gas and dust emission at 1.3 mm in this disk. The analysis reveals there is still a large amount of (primordial) gas extending out to 250 AU, i.e. inside the rings observed in scattered light. HD141569A is thus a hybrid disk with a huge debris component, where dust has evolved and is produced by collisions, with a large remnant reservoir of gas.

Keywords. stars: circumstellar matter, protoplanetary disks, radio-lines: stars.

A debris disk still containing gas

HD141569A is a 5±3 Myr old star (Merín *et al.* 2004), of spectral type B9.5V/A0Ve, located 116±8 pc away (van Leeuwen 2007). With a stellar mass of 2 $M_{\odot}$, the HD141569A system appears to be in an intermediate evolutionary stage between protoplanetary and debris disks.

A debris disk has been discovered first by *IRAS*, with an infrared excess of the same order of magnitude as β Pictoris ($L_{disk}/L_{\star}=8\times10^{-3}$; Sylvester *et al.* 1996). Optical images reveal that the debris disk around HD141569A is very complex, with a double-ring architecture, a large inner depletion within 125 AU, and arc and spiral features (e.g. Augereau *et al.* 1999, Biller *et al.* 2015). The dust appears to be of second generation origin, i.e. produced by collisions, as indicated by the timescale for collisions of $\sim10^4$ years which is 100 times less than the age of the star (Boccaletti *et al.* 2003).

In addition to its impressive debris disk, CO gas has been detected around HD141569A (Zuckerman *et al.* 1995; Dent *et al.* 2005). NIR CO and other atomic lines have also been observed (Goto *et al.* 2006; Thi *et al.* 2014). The inferred total remnant mass of gas has thus been estimated in the range 80-135 $M_{\oplus}$ (Jonkheid *et al.* 2006).

We present here the first resolved maps of the ^{12}CO J=2-1 and ^{13}CO J=2-1 emission lines, which we obtained in 2014/2015 with the Plateau de Bure Interferometer array. The

Table 1. Best fit parameters from DiskFit gas modeling

	Inclination (°)	**Postion Angle** (°)	R_{out} (AU)	R_{in} (AU)	T_0 (K)	q
^{12}CO	54.4 ± 0.4	86.1 ± 0.2	254 ± 3	22 ± 1	44 ± 2	0.35 ± 0.05
^{13}CO	57 ± 2	88 ± 1	253 ± 15	21 ± 7	16 ± 4	0.2 ± 0.3

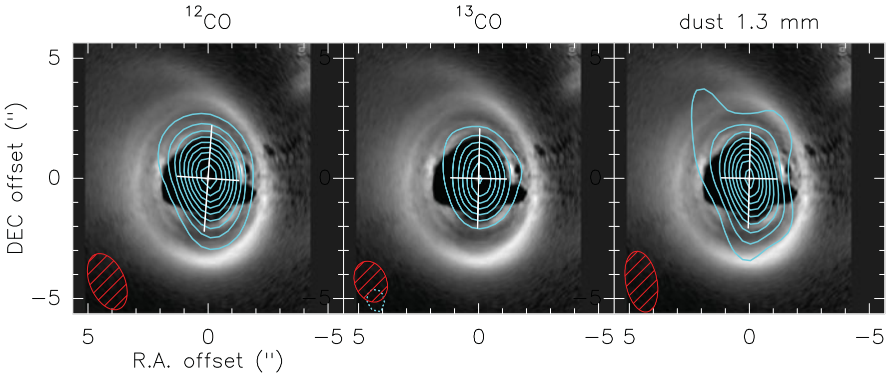

Figure 1. Integrated intensity of the CO and dust emission at 1.3 mm, superimposed to the *HST* scattered emission (Clampin *et al.* 2003). The cross indicates the position angle and aspect ratio as determined from gas modeling. Left: ^{12}CO J=2-1 emission, contour spacing: 6σ, i.e. 5.5×10^{-1} Jy beam^{-1} km s^{-1}. Beam size: $2.48 \times 1.45''$. Middle: ^{13}CO J=2-1 emission, contour spacing: 3σ, i.e. 7.8×10^{-2} Jy beam^{-1} km s^{-1}. Beam size: $1.76'' \times 1.32''$. Right: continuum emission, contour spacing: 3σ, i.e. 2.0×10^{-1} mJy beam^{-1}. Beam size: $2.57'' \times 1.31''$.

integrated intensity maps of the gas are displayed in Figure 1, as well as the continuum emission at 1.3 mm. We have modeled the data in the uv-plane using the code DiskFit (Piétu *et al.* 2007), based on a power-law description of the physical parameters, e.g. $T(r) = T_0(r/R_0)^{-q}$. Table 1 shows the parameters determined from this modeling for the ^{12}CO and ^{13}CO. The disk extends from ∼20 AU to 250 AU. From the ^{12}CO/^{13}CO line ratio, the ^{12}CO appears to be still optically thick while the ^{13}CO is optically thin. The temperature is thus best determined from the ^{12}CO modeling (∼45 K at 100 AU, a typical value for an A star). The ^{13}CO better probes the surface density, which is here ∼30 times less than around typical HAeBe disks, like MWC480.

HD141569A is thus a 'hybrid' disk with a large gas component, likely primordial, and an impressive evolved debris disk. The flux at 1.3 mm is 3.5±0.1 mJy, a low value in agreement with fast evolution of the dust. The links between gas and dust properties in this and other star/disk systems have to be studied in more detail, in particular to better understand the disk dissipation/evolution mechanisms which influence the shaping of young planetary systems.

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