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The dust content and the kinematics of NGC 4565

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Using the IRAM 30-m telescope, we have mapped the λ1.2 mm continuum emission and the ^{12}CO J= 1–0 and 2–1 line emissions in NGC 4565. We selected this edge-on Sb galaxy because, contrary to the nearby galaxies mapped so far at 1.2 mm, it is relatively weak in the CO lines, but strong in the HI λ 21 cm line.

The CO emission shows a ring-like distibution plus a central nuclear source. It peaks between $1'$ and $1.5'$ from the center and tapers off for $R > 2'$; it is much less extended than the HI emission, which remains flat until $R = 5 \ldots 6'$. The λ1.2 mm continuum, which is mostly thermal emission from dust, has an intermediate distribution. It exhibits the central peak and compact ring observed in CO *plus* a weaker component extending well beyond the limits of the CO map. This is the first time dust emission from extragalactic HI clouds is detected at mm or submm wavelengths.

The velocity field derived from CO can be described in terms of a circular rotation (solid body rotation between 0 and 4 kpc, constant velocity further out) plus non-circular 'streaming' motions near the center and in the molecular ring. The non-circular motions are explained by the presence of a central bar and of a spiral density wave. The presence of streaming motions associated with spiral arms was already proposed by Rupen (1991) to explain the HI velocity field. That of the bar could explain the boxy shape of the central bulge.

The CO brightness distribution

The CO brightness distribution along the major axis shows a central peak surrounded by two ring-like maxima and resembles those in NGC 891 and other edge-on spirals; for the adopted distance of 10 Mpc the dimensions are about equal to the width of the central molecular disk and the size of the molecular ring of the Galaxy. However, the CO surface brightness and in particular the relative strength of the central peak are much weaker in NGC 4565. The spectra near the ring maxima are double-peaked; these narrow structures are most probably spiral arms.

The distribution of the CO brightness is very different from that of the HI: the HI is more extended but less concentrated in particular structures. The 'molecular ring' is weakly seen, but the center is deficient of atomic gas.

The λ 1.2 mm continuum distribution

The λ 1.2 mm continuum emission appears concentrated along a narrow ridge that follows closely the dusty optical disk; it extends up to its NE edge, at 19 kpc from the center. In the SW our map did not reach the edge of the disk. On both sides, however, the continuum emission is significantly more extended than the CO brightness distribution, Obviously, the λ 1.2 mm continuum emission is intermediate between those of the CO and the HI. It shows three equal strength peaks about coincident with that of the CO and an extended component similar to HI.

Moreover, the outer part in the NE shows the warp (which is known e.g. from the HI observations) in addition to the continuing ridge along the major axis. The warp starts at a radius of 10 kpc from the center and reaches a height of about 2.4 kpc above the plane at the end of the disk.

The kinematics

The rotation of the disk can be described with two components: rigid solid body rotation out to a radius of 4 kpc and differential rotation with a constant velocity of 250 km/s outside of this radius. Closer examination exhibits several systematic variations in the 'molecular ring' and the outer parts which are most likely attributed to spiral arms; similar structures are seen further out in the HI data and can be consistently fitted with a spiral structure having a pitch angle of about 13°. The streaming motions associated with the spiral arms furthermore explain the distortions of the velocity field near the center.

The central spectrum shows broad wings and additional components which hint at a bar which is much weaker than in NGC 891; this bar could however explain the box-shaped bulge of this galaxy.