The Edge-on Spiral NGC 5907 Imaged by Spitzer/IRAC

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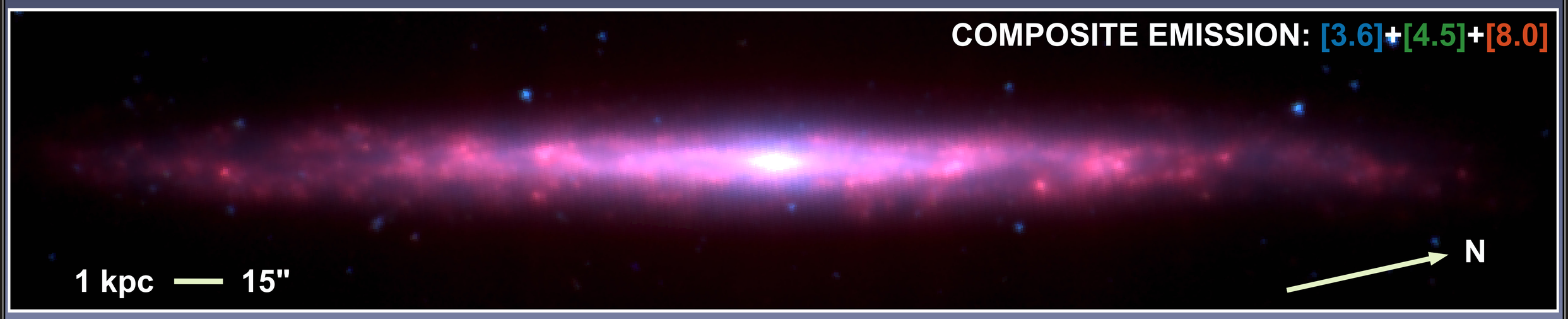


IRAC Seeks (Baryonic) Dark Matter:

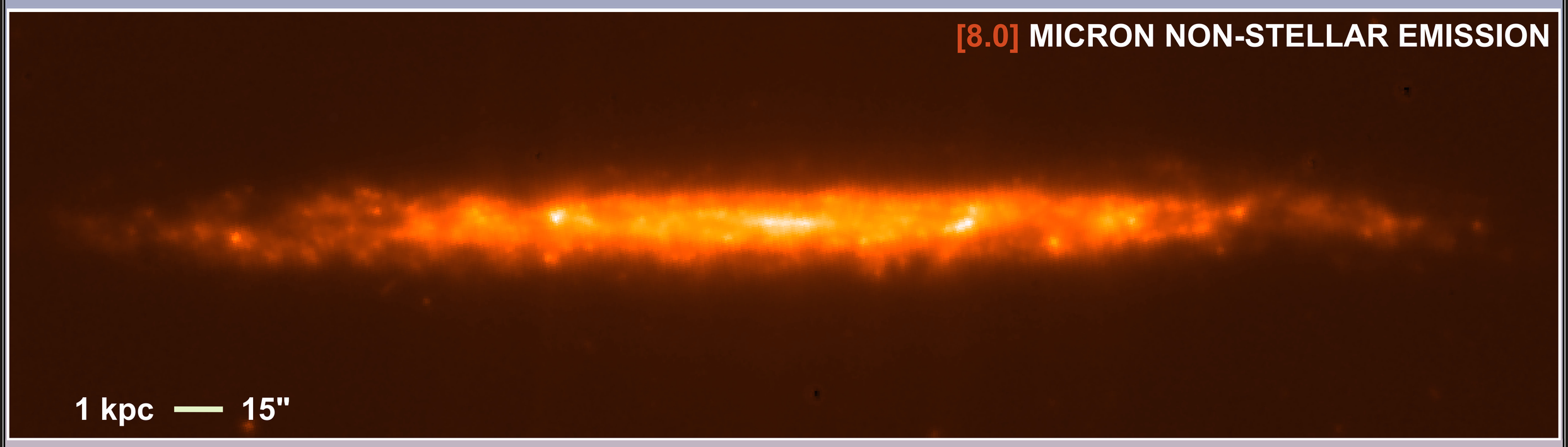
MACHO studies suggest that the halo of the Milky Way may contain large numbers of brown dwarfs. These mid-infrared images show NGC 5907 as observed with IRAC in an attempt to measure the possible contribution of brown dwarfs to the halo mass in this Milky Way analog. It is nearby (14 Mpc) and oriented nearly edge-on, an optimal candidate for detecting the faint, diffuse emission that could arise from the 0.8-1.4 x 10^{11} solar mass (Casertano 1983, van der Kruit & Searle 1982) halo. NGC 5907 is one of four edge-on spirals being imaged in this program (the others are NGC 891, NGC 4244, and NGC 4565) to search for a mid-infrared component to the halo emission -- if the halo is partially made up of brown dwarfs, IRAC is the ideal instrument to detect them.

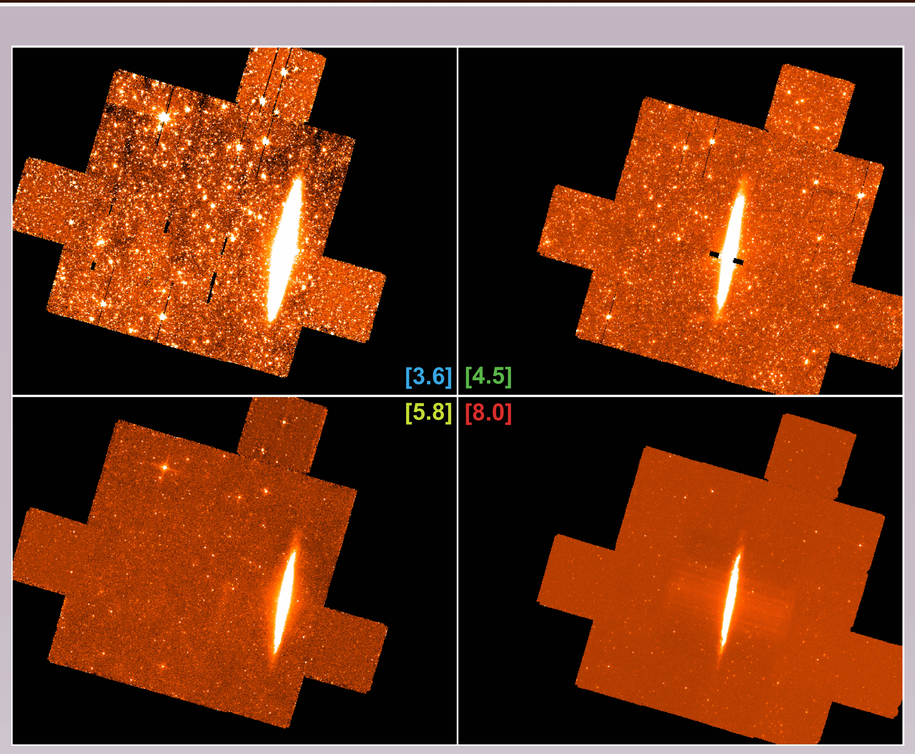
Mid-Infrared Emission from the Disk and Bulge:

NGC 5907 was observed in 2003 December in all four IRAC bands with a 20' x 20' map built up of 10 100-s dithered exposures taken in high-dynamic range mode. The image shown above is a composite of IRAC images from a portion of that map, showing the disk at 3.6, 4.5, and 8.0 microns. There is an obvious but diminutive bulge (white), and disk emission that shows a progression from smooth, monotonic decrease with radius at the shorter wavelengths to a relatively clumpy distribution at the longer wavelengths. Far from the galaxy we measure backgrounds of roughly 0.027, 0.014, 0.024, and 0.023 MJy/sr; this estimate excludes the zodiacal light which was modeled and then subtracted by the pipeline from each individual exposure.

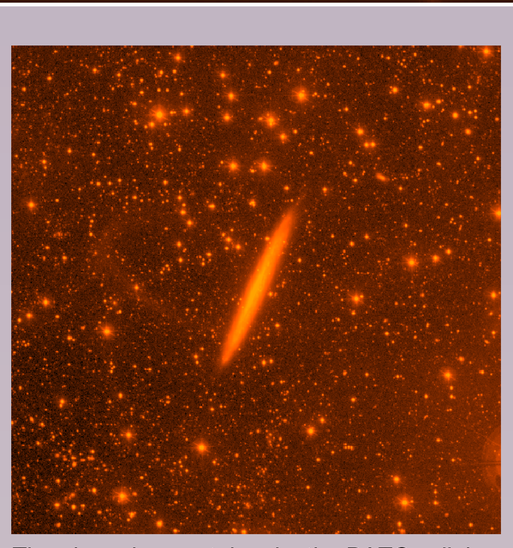
Non-stellar Light: The Disk, A Bar, Spiral Arms

Because extinction is so low at mid-infrared wavelengths, it is possible to estimate the stellar contribution to the 8.0 micron emission by scaling and subtracting the emission at 3.6 and 4.5 microns. We have done this, assuming colors appropriate for a late-type galaxy, and the image below is the result. Even at this high inclination, spiral arms traced by the 8.0 micron emission from PAHs are easily discerned. A previously unknown nuclear bar or disk feature is also seen. In general the PAH emission traces the spiral structure and likewise the star formation in these regions that until now had been hidden from scrutiny by extinction (but see below). Ellipse fitting to the non-stellar disk emission yields a consistent estimate of 0.92 for the ellipticity, implying an inclination of 85.4 degrees, less than the 87-degree figure cited in the literature.

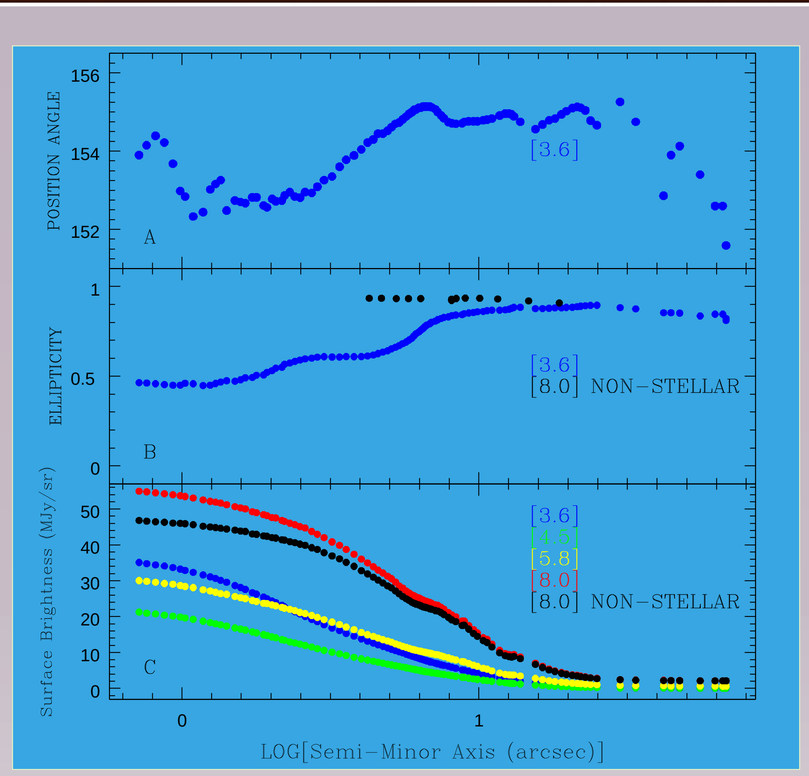




Here we show the four IRAC wide-field mosaics, stretched to emphasize faint structure outside the disk. These were constructed with the MOPEX software package after applying multplexer bleed, column pulldown, and overlap correction to the BCD (S9.5). Some instrumental artifacts (stray light, residual images) have been masked. Others, e.g. banding in the 8.0 micron image, are still present at this stage of the data reduction. These images establish upper limits to the halo emission of 0.0016, 0.003, 0.013, and 0.018 MJy/sr in IRAC channels 1-4, respectively, inside a ~400 square arcsec region adjacent to that surveyed by Zepf et al 2000, AJ, 119, 1701 with HST/NICMOS. Further processing should yield even stronger limits, after PSF modeling and subtraction eliminates a substantial fraction of the foreground contamination.



The above image, taken by the BATC collaboration, is the deepest yet taken of the halo region at visible wavelengths. It extends down to ~29 mag/arcsec^2 at 8020 Angstroms (Shang et al 1998, ApJ, 504, L23, and Zheng et al. 1999, AJ, 117, 2757). This observation revealed a tidal arc not yet seen in the partially-reduced IRAC mosaics at left.



We used IRAF:ELLIPSE to fit two-dimensional isophotes to the relatively smooth emission at 3.6 microns; the average measured surface brightness is plotted in blue above as a function of semi-minor axis. Surface brightness in the other three IRAC bands and the estimated non-stellar image was measured within the same fitted ellipses. The data in panel C suggest that the non-stellar emission may have a longer scale height than the 3.6 micron stellar emission; this would imply that at least a significant fraction of the 8 micron emission originates in cirrus, in addition to the portion already associated with star-forming regions. Panel A shows a warp.

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