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The Continuum Spectra of the Core and Hotspots of Cygnus-A in the Millimetre and Submillimetre

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Abstract.
Submillimetre imaging ($350\,\mu$m to $850\,\mu$m) and millimetre photometry (1.35 mm and 2 mm) observations, obtained with SCUBA (Holland et al. 1998), are used: (1) to investigate electron aging for synchrotron emission and (2) to determine the dust content in Cygnus-A.

Cygnus-A (3C405) is a cD galaxy with V=15 at z=0.0567 and shows spectacularly symmetrical radio lobes and jets. It has a FRII-type radio structure: powerful radio lobes with $L > 10^{35}$ W at 178 MHz which are edge-brightened with prominent 'hotspots'. For $H_0 = 75\,\mathrm{km^{-1}s^{-1}Mpc^{-1}}$, the distance is 227 Mpc giving a plate-scale of 1.1 kpc/arcsec. To most AGN pundits Cygnus-A is the archetypal 'quasar' on the plane of the sky with the central AGN buried in a dusty molecular torus.

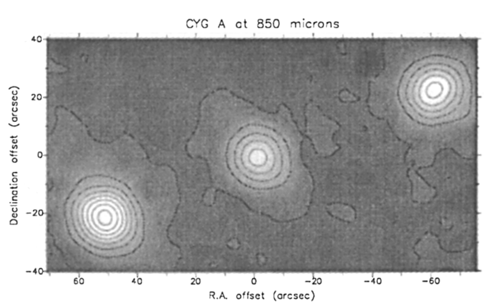

Figure 1. The hotspots and central core at $850\,\mu$m. The rms is 40 mJy/beam.

The hotspots show a well defined power-law spectrum between 1 GHz and 700 GHz. The spectral indexes ($S_\nu \propto \nu^\alpha$) between 140 GHz and 677 GHz are $\alpha = -1.04 \pm 0.01$ and $\alpha = -0.99 \pm 0.01$ for hotspots A (northern) and D (southern), respectively. The lack of spectral steepening means no electron aging to the highest frequency of ~ 677 GHz. If we assume an equipartition magnetic field energy of 30 nT, this gives a lifetime for the radiating electrons at $450\,\mu$m of

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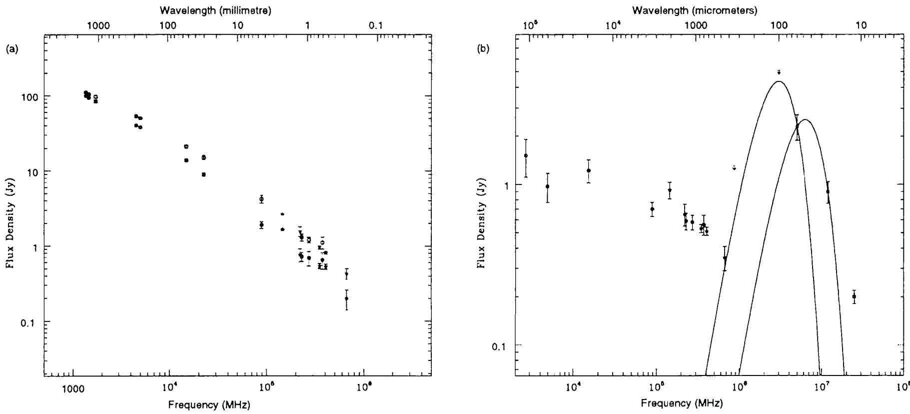

Figure 2 The spectral energy distribution of (a) the hotspots A (open circles) and D (solid circles) and (b) the central core. The SCUBA data points are indicated by asterisks and stars. All the upper limits are 3σ. The two curves in (b) represent emission from greybodies with temperatures of 37K and 85K with an emissivity index, β, of 1.3 (Robson et al. 1998).

$< 10^4$ y. However, it is known from 3 mm interferometry observations that the hotspots are 2 - 3 kpc across. Therefore the electron diffusion speed is either $\sim$ c (uncomfortable), or more likely non-localized relativistic particle acceleration is taking place.

The Core synchrotron spectral index is much flatter with a value of -0.6 ± 0.1. Re-analysis of the *IRAS* HIRES data products confirm previous measurements at 25 and 60 μm but show that the revised 100 μm upper limit is not helpful in determining dust parameters. With our new submillimetre data, we constrain the non-thermal contribution to *IRAS* and *ISO* fluxes. In particular with our photometry value at 450 μm, and the two *IRAS* measurements, we constrain the dust temperature between 37 K and 85 K and corresponding dust masses of $1.0 \times 10^8 M_\odot$ and $1.4 \times 10^6 M_\odot$, respectively. Our results are consistent with new, better-constrained (because of a good number of data points at the critical part of the spectrum) dust temperature of 52 K and dust mass of $5 \times 10^6 M_\odot$ obtained by Haas et al. 1998 using new *ISO* data from 60 μm to 180 μm. Further details and analysis of the SCUBA data are presented in Robson et al. 1998.

References

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Holland W.S. et al., 1998, MNRAS, in press

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