MM emission from quasars

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Abstract. 1.3mm continuum observations for a complete sample of opti cally selected southern quasars show that most objects have flux densities below ≈40mJy at that wavelength. This clearly indicates that previously claimed detections at Jy level are erroneous. The sample is divided into radio-quiet and radio-loud objects. While for the first group a thermal origin of the FIR emission is very likely the latter group shows energy distributions dominated by Synchrotron radiation.

1. Introduction

Since IRAS data are available for a number of quasars (Neugebauer et al. 1986, Sanders et al. 1989) a controversial discussion about the origin of FIR emission has started. An observational breakthrough in this field was achieved by Chini et al. (1989a) who presented 1.3mm data of all northern radio-quiet quasars in the Neugebauer sample. The steep spectral turnover between IRAS and mm-data demonstrated that dust emis sion on kpc scale may explain easily the observations, whereas non-thermal models have to adopt exotic electron energy distributions in order to describe the observed spectra. Likewise, the mm/submm investigation of radio-loud quasars observed by IRAS (Chini et al. 1989b) demonstrated that all steep spectrum and 50% of the flat spectrum quasars show a significant spectral turndown at submm wavelengths, dividing the radio and FIR emission into two separate components. Again, the FIR emission was interpreted to originate from dust in a cool disk heated by the active nucleus; the orientation of the quasar relative to the observer and its isotropic luminosity determine whether it appears as a radio-quiet or radio-loud object.

Long before this picture of thermal dust emission from quasars was established, Sherwood et al. (1981, 1982) reported on the detection of 1mm emission from a complete sample of 17 optically selected southern quasars brighter than 17.6mag. The observed flux densities were above 1Jy. From the steep spectral index between the radio range and the 1mm data in was suggested that the FIR/submm emission may be dominated by thermal radiation. Robson et al. (1985) could not confirm those results

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with a slightly better sensitivity and, as a consequence, the strong thermal mm-emission from these quasars remained doubtful.

2. Results

In the following, preliminary results obtained during two test runs with the MPIfR bolometer system at the SEST are reported for this complete optically selected sample of quasars. Although the sensitivity of the present 1.3mm observations exceeds the former attempts by at least a factor of 20, there are only two marginal detections at about 40mJy while the rest of the objects have 3σ upper limits of the same order. Therefore, it is almost certain that previously reported detections at Jy level must have suffered from instrumental effects if one does not assume violent long-term variability at mm wavelengths.

3. Discussion

One may divide the current sample into two distinct categories according to their radio properties: 8 quasars show radio emission between 20 and 800mJy whereas their optical flux density is of order 0.5mJy. Having the same optical brightness, the remaining 9 quasars are "radio-quiet" in the sense that there was no radio emission detected down to a level of 10mJy. This indicates that the ratio of radio-to-optical luminosity is at least one - if not several - orders of magnitude lower in the "radio-quiet" group compared to the "radio-loud" subset. Likewise, quasars in the "radio-loud" group emit more than twice the energy than objects in the "radio-quiet" group: the average luminosity of the radio-loud objects is $113\pm53\ 10^{12}L_{\odot}$, the corresponding value for the radio-quiet objects is $<47\pm7\ 10^{12}L_{\odot}$. It should be noted that an equal amount of energy is emitted in the range from optical to X-ray wavelengths. Having established a "radio"-division of this optically selected sample, we want to discuss in the following both categories in more detail.

3.1 Radio-loud quasars

The similarity of the spectral shapes from X-rays to 1.3mm is striking: The spectral index between X-rays and 60μm is $\alpha_{IRX} = -1.29\pm0.04$ - a value that is typical for all types of quasars (Chini et al. 1989a,b). Even in the radio regime there is a common behavior in the sense that the spectra keep rising roughly until 11cm and turn over beyond that wave length. Significant deviations only occur in terms of the absolute radio flux densities which differ by an order of magnitude at their extreme values. The average spectral index between the radio range and 60μm is $\alpha_{RIR} = -0.32\pm0.04$ in agreement with values found for flat spectrum radio quasars. The IRAS data for one of the quasars (0420-388) are consistent with this interpretation although the upper limits from 12 to 100μm do not provide a serious constraint. The new 1.3mm observations support the picture of a single flat spectrum synchrotron component dominating the mm and FIR range.

3.2 Radio-quiet quasars

The spectral index between X-rays and 60μm is α_{IRX} = −1.21±0.01 − a value similar to that derived above. The existing upper limits in the radio regime do not completely rule out the existence of a flat spectrum synchrotron component: Taking the upper limits at their face value, one obtains an average spectral index α_{RIR} < −0.27±0.02 that is still compatible with the α_{RIR} result for the radio-loud sample. In this respect, the classification of the objects as "radio-quiet" is uncertain. A general answer to this question requires radio data of much higher sensitivity.

Next we want to investigate the possibility of a thermal bump at FIR/submm wavelengths as seen in genuine radio-quiet quasars. Chini et al. (1989a) have presented spectra of radio-quiet quasars from X-ray to IRAS wavelengths. It was shown that the energy distributions of radio-quiet objects keep rising over the entire wavelengths range with a single spectral index α_{XIR} = −1.25±0.14. As demonstrated above, the present spectra have an identical slope. Therefore, we can extrapolate to the flux densities expected at 60 and 100μm and obtain values of a few hundred mJy at the maximum. This is slightly below the detection limits of IRAS in the normal survey mode so that the missing FIR fluxes can not serve as an argument against a thermal bump.

The only object detected at IRAS wavelengths is quasar 0530−379 with the lowest redshift in the sample of 0.29. Its spectral index from 0.5 to 25μm is −1.08±0.01 and thus still consistent with the general value of α_{XIR} as discussed above. On the other hand, the observed 12 and 25μm flux densities and the radio limits would yield a positive α_{RIR}, in contrast to all known synchrotron components in that spectral range. It is therefore likely that the FIR emission originates from a separate thermal component and the classification as a radio-quiet quasar is rather certain for this source.

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