EXTENDED INFRARED EMISSION IN SEYFERT GALAXIES

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ABSTRACT. We have analyzed far-IR (IRAS) data for a sample of optically selected Seyfert galaxies. The far-infrared emission is uncorrelated, or at best weakly correlated, with the UV-optical emission from these sources. We find the far-IR emission to be extended in a number of objects. We discuss the possibility that Seyfert galaxies are undergoing circumnuclear bursts of star formation. For comparison with the large aperture IRAS data we have also obtained new ground-based measurements at 10 and 20 μm for a sample of 17 Seyfert galaxies. Conclusive evidence for extended 10 and 20 μm emission is seen in 7 out of 17 objects. In addition, almost all of the objects have ground-based fluxes which are smaller than those measured by IRAS. Finally, for five objects the emission appears to be more extended at 10 μm than at 20 μm. This would be expected if the 10 μm emission arose, in part, from a population of very small grains for which single photon heating is important.

In a recent paper Rodriguez Espinosa, Rudy and Jones (1986, hereafter **Paper I**) have analyzed the far-IR (IRAS) emission of a sample of optically selected Seyfert galaxies. They concluded that the emission from the active nucleus does not account for the bulk of the far-IR emission seen by IRAS. Ths claim was based (see **Paper I**) on the following facts:

i) The far-IR emission originates in an extended region beyond the typical size of the active nucleus in a number of Seyfert galaxies, and

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ii) In most Seyfert galaxies in our sample, the non-thermal UV-optical continuum luminosity is not large enough to account for the far-IR emission via dust reradiation of the UV-optical continuum emission.

Further studies of the IRAS data for a relatively large sample of optically selected Seyfert galaxies (Rodriguez Espinosa, Rudy and Jones 1987, hereafter **Paper II**) show that the far-IR IRAS fluxes at 25, 60 and 100 μm are uncorrelated or very weakly correlated with the UV-optical continuum flux, and the infrared fluxes at 3.5 and 10.6 μm. This latter group of fluxes is associated with emission from the active nucleus, and the lack of correlation with the IRAS fluxes is in agreement with the earlier results of **Paper I** concluding that the active nucleus is not the principal source of far-IR emission.

Paper II also compared the far-IR luminosities of the Seyfert galaxies in our sample with the far-IR luminosities of both normal spiral galaxies and starburst galaxies with the following results:

i) Normal spiral galaxies have far-IR luminosities that are, on the average, an order of magnitude less luminous than Seyfert galaxies,

ii) The far-IR luminosity distribution of both Seyfert galaxies and Starburst galaxies are identical, and

iii) The distribution of spectral indices $\alpha(60\text{-}100)$ is also the same for the Seyfert galaxies and the starburst galaxies. However, the $\alpha(25\text{-}60)$ spectral indices of the Seyfert galaxies are much bluer than those of the starburst galaxies, indicating the presence in the Seyferts of additional emission at shorter wavelengths from the active nucleus.

Based on the results, **Paper II** concluded that star formation episodes produce the bulk of the far-IR emission in Seyfert galaxies. Furthermore, at far-IR wavelength, Seyfert galaxies are indistinguishable from starburst galaxies, suggesting a possible link between star formation and the active nucleus.

To search for evidence of star formation in Seyfert galaxies in the form of spatially extended mid-infrared emission, we have obtained 10 and 20 μm observations with the 3m IRTF on Mauna Kea of a sample of 17 Seyfert galaxies for which IRAS measured 25 μm fluxes of ≥ 1 Jy. The results, which will be discussed in detail by Rudy and Rodriguez Espinosa (in preparation), can be summarized as follows: after correcting the data for the different bandpasses and spectral indices, they were compared to the 12 and 25 μm measurements of IRAS. We find:

i) Seven of the objects measured through a 6" aperture have ground-based fluxes which are substantially smaller than the large aperture IRAS values.

ii) Sixteen of the 17 objects have ground-based fluxes in the 10 μm region which are smaller than those measured by IRAS; in the 20 μm region the same is true in 14 of the 17 objects.

iii) For the 7 objects in result (i) we conclude that star formation is present at significant levels; for the remainder of the objects we can say only that any large region of star formation must be circumnuclear, or at least concentrated towards the nucleus.

The fact that for a fraction of the objects the 10 μm emission is more extended spatially than the 20 μm emission supports the conclusion of Wynn-Williams et al. (1986) that there exists a population of very small dust grains for which single photon heating is important.

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