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A NEW METHOD TO DETERMINE THE RELATION BETWEEN DUST MASS AND SUBMM LUMINOSITY.

A. James,[1] L. Dunne,[1] S. Eales[1] and M.G. Edmunds[1]

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Using a new technique we have determined a value for the dust mass absorption coefficient at 850μm. We find $\kappa_{850} = 0.07 \pm 0.02 m^2 kg^{-1}$

To apply the technique we need a galaxy which has submillimetre and far-infrared flux measurements, a measure of its total gas mass and its metallicity. The dust mass of the galaxy is then given by two equations:

$$M_d = M_g \times Z \times \varepsilon \times f, \qquad (1)$$

where M_g is the mass of gas in the galaxy, Z is the metallicity relative to solar, ε is the ratio of the mass of metals in the dust to the total mass of metals and f is the ratio of the mass of metals to the mass of gas for gas with solar metallicity, we estimate $f = 0.019$, and;

$$M_d = \frac{S_{850} \times D^2}{\kappa_{850} \times B_{850}(\nu, T)}, \qquad (2)$$

in which S_{850} is the flux density at 850μm, D is the distance of the galaxy, $B_{850}(\nu, T)$ is the value of the Planck function at 850μm, T is the dust temperature and κ_{850} is the mass-absorption coefficient at 850μm. We then set these two equations equal to one another, and as long as we know ε, we can estimate κ_d.

To calculate ε, we have assumed the solar metal abundance given in Pagel (1997) and multiplied this by two thirds to obtain cosmic metal abundances. Assuming the depletions given by Whittet (1992) we obtain a value for ε of 0.456

We applied this method to all the galaxies that we are aware of which have metallicity measurements and submillimetre measurements, 22 objects in total.

In Fig. 1 we have plotted the dust masses calculated by the two different methods against each other. The solution of a least-squares fit on the data was consistent with a slope of unity. This suggests that the properties of the dust, in particular ε and κ_d, are similar for dwarf and giant galaxies alike. If then the value for κ_d that we initially assumed for plotting Fig. 1 is correct, the points should lie on a line of slope unity passing through the origin. By measuring the actual offset of the points from the line, we can calculate a new value for κ_d. We find $\kappa_d = 0.07 \pm 0.02 m^2 kg^{-1}$.

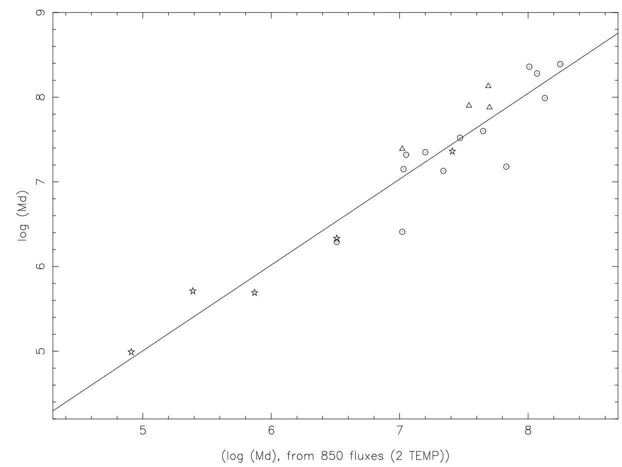

Fig. 1. The abscissa shows the dust mass calculated using equation 2 and the ordinate displays the dust mass determined with equation 1. The line is a least-squares best fit through the data. See James et al. (2002) for an explanation of the symbols.

The main uncertainty in the method is the basic assumption that the fraction of metals in dust (ε) is a universal constant. If this is not correct, our estimate of this constant from observations of the interstellar medium in our own galaxy will not be applicable to other galaxies. However, the scatter around the best fit line in Fig. 1 is only a factor of 2 in the ordinate. This scatter includes all observational errors, as well as galaxy-to-galaxy variations in κ_d and ε. On the extreme assumption that all the scatter is caused by variation in ε, we estimate that the galaxy-to-galaxy variation in ε can only be a factor of ~ 2. If this extreme assumption is correct, then our estimate of κ, would have an error of a factor of ~ 2 for an individual galaxy.

REFERENCES

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[1] Dept. of Physics & Astronomy, Cardiff University, 5 The Parade, Cardiff, CF24 3YB, UK (a.james@astro.cf.ac.uk).