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Review of the doctoral thesis of Emily Lynette Kosmaczewski entitled „Multi-Wavelength Diagnostics of Cosmic Dust: From Galactic Dust Clouds to Young Active Galaxies"

Summary of the thesis

Dust is an important element of galaxies, influencing its optical energy output, acting as a coolant and as a catalyst for molecule formation. The thesis presents the analysis of dust in radio galaxies and a dark cloud.

Chapter 2 presents statistical analysis of the mid-infrared data for young radio galaxies. The main conclusion is that powerful jets can be launched in galaxies with a wide range of star formation properties, as indicated by their broad range of mid-infrared colours. Comprehensive comparison to other samples are also presented.

Chapter 3 presents mid-infrared observations of DC314.8-5.1, a dark cloud containing a reflection nebula, which is about to start forming stars. In particular, the mid-infrared spectra from the *Spitzer* telescope are analysed. The correlation between the fraction of large grains and the ionised fraction shows the destruction of small grains in the high intensity radiation fields.

This line of research is continued in Chapter 4 by looking for pre-main sequence stars and young stellar objects in the same dark cloud. None was found indicating that indeed this cloud has not started star formation yet. This is achieved using the X-ray and ultraviolet images from the *Swift* satellite within a proposal led by Emily Kosmaczewski, the new reduction of *Spitzer* photometry, and archival data.

Contribution to the field and the conclusion of this review

The fact that the range of mid-infrared colours of AGN is broad (chapter 2) has been observed (Figure 2.6 in the thesis), and it is important that this applies to the youngest radio galaxies as well, as shown in the thesis. It is also important to note that this chapter reports different mid-infrared colours of the young radio galaxies (with a broad range of colours) and FRII galaxies (with colours indicating mostly passive galaxies), which are though to be evolutionary related. This indicates that the newly launched jet will soon have a negative effect on star formation in these galaxies. The influence of the jet activity on star formation is a key ingredient of our understanding of galaxy evolution, so this is a significant result.

The research on DC314.8-5.1 is important from the point of view that dark clouds are sites of future star formation, so can reveal what conditions are needed for the onset of this process. Chapter 4 confirms that DC314.8-5.1 indeed hosts no star formation, which opens the possibility of more detailed investigation on its gas state and chemistry. Chapter 3 reports the discovery of the effect on high intensity radiation field on small grains. Such process must be prevalent in clouds that have recently started forming stars and can greatly influence the interplay of star formation and properties of interstellar medium.

I conclude that this thesis represents a valuable contribution to the field of galaxy evolution and star formation and therefore I recommend granting the doctoral degree to Emily Kosmaczewski.

Below I point out the weaknesses of this thesis with the aim of helping to improve the future work.

Interpretations and broad conclusions

My main criticism of the thesis is that in terms of interpretations it does not do justice to the collected data and performed measurements. A lot of different values are measured and compared to other datasets or samples. However, very few general conclusions are drawn. One could potentially learn a lot more from this work on some important questions on how dust evolves and how star formation and jet activity interplay with these processes. Some general conclusions are provided (as highlighted above), but they are harder to find and not elaborated on.

Strength of dust continua

Fig. 3.10 (p. 66) shows the normalisations of dust components at various temperatures. The conclusion is drawn that "the most prominent dust continuum component corresponds to the temperature of 40 and 35 K, having orders of magnitude higher normalizations than the hotter counterparts". I do not think this can be inferred from this figure. The normalisations τ_m are defined, so that the total intensity of dust is (eq. 31 on p. 66):

$$I_\nu^{(\mathrm{dust})} = \sum_{m=1}^{8} \tau_m \frac{B_\nu(T_m)}{(\lambda/\lambda_0)^2},$$

where B_ν is the black-body function at a temperature T_m. Hence, the normalisation τ_m has little physical meaning and if one wants to determine which dust component is more prominent, one would need to compare the entire factors under the summation, not just the normalisations. This is connected with the fact that a unit mass of dust at higher temperature is brighter than the same amount of cold dust (when we consider bolometric luminosities).

Such comparison is done on Fig 3.3 and 3.9 where fluxes of all the dust components are plotted as red lines. They are not labelled, so it is difficult to see how their contribution depends on temperature, but it is obvious that at least up to 20 μm the emission is dominated by the components peaking at 7–12 μm, so it is hot dust, not cold (35–40 K) dust, identified as dominant in the sentence quoted above. It is actually expected — it would be very surprising if cold dust dominated the emission in the mid-infrared.

Molecular hydrogen line

In section 3.6.2 (p. 72) it is briefly mentioned that the molecular hydrogen line was only detected at high distances from the ionising star, but its flux remains constant there. Fig. 3.13 (top) shows that there may be some positive trend, so it would be a good idea to test its significance and, if it is significant, then something can be learned about the dissociation of the H_2 molecule by the ionising flux of the star.

Minor comments

I have several minor comments.

- In LaTeX in order to obtain 6.″1 instead of 6″.1, one can use `$6\farcs1$` or `$6.\!\!^{\prime\prime}1$`
- The dashed outlines on Fig. 3.11 are not explained in the caption.
- In Fig. 4.2 I could not find the "S" X-ray source mentioned in the caption.
- Fitting a modified black body to the Planck fluxes (p. 79) results in the measurement of the dust not gas temperature.
- Source S looks significant on Fig. 4.3, but the text states that it is "a detection with a signal-to-noise of ~ 1.63" (p. 83). I would then call it a non-detection, so either this is a typo, or something is wrong, probably with the error estimate.
- The meaning of the black and blue dashed lines on the bottom-left panel of Fig. 4.6 is not explained.

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