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Referee 's report of the PhD thests of Ms Emily Lynette Kosmaczewski entitled „Multi-Wavelength Diagnostics of Cosmic Dust: From Galactic Dust Clouds to Young Active Galaxies"

The PhD thesis of Ms Emily Kosmaczewski, written under the supervision of dr hab Łukasz Stawarz, describes an original work related to the multi-wavelength inspection of cosmic dust across the universe. The research was partly supported by The Fulbright Program, The Astronomical Observatory of the Jagiellonian University, and The Polish National Science Centre grant 2016/22/E/ST9/00061 (supervisor of Ms Kosmaczewski is the PI of the grant). The work presented in this dissertation by Ms Kosmaczewki concentrates on the investigation of dust properties in various astrophysical scales. The whole analysis performed by Ms Kosmaczewski combined with multi-wavelength datasets, assures a proper understanding of the main physical processes described in the PhD Thesis.

The Thesis was written in English and prepared as a consistent collection of three articles published/submitted in scientific journals. Ms Kosmaczewski is the first author of all three articles. The dissertation consists of five Chapters, including a complete introduction to the subject. The dissertation contains acknowledgements and two abstracts (one in Polish and one in English). At the very end of the Thesis, one can find the literature. Ms Kosmaczewski also provided co-authors' contribution statements to fulfil the requirements for the PhD thesis written in the form of a collection of published articles.

The Introduction describes the Interstellar Medium and its main components. Then Ms Kosmaczewski focused on cosmic dust as a primary ruler of the cold molecular gas and cold neutral medium. The Introduction presents the formation process of cosmic dust and its manifestation in the mid-infrared range of galaxy spectra (PAH) and γ-ray emission (cosmic ray interactions). Moreover, the description of the molecular clouds in starforming and active

galaxies is shown in the same Chapter. Additional information on the observational possibilities is added at the end of this part of the Thesis. To summarize, the Introduction is very informative and contains all the needed information to present the motivation for the PhD subject. This comprehensive description of a scientific problem is an in-depth introduction to the three scientific papers presented in the following parts of the Thesis.

Chapter 2 consists of the article published in the Astrophysical Journal in 2020, titled "Mid-infrared Diagnostics of the Circumnuclear Environments of the Youngest Radio Galaxies" (hereafter, Paper I). This paper was written by Ms Kosmaczewski, her supervisor, and seven other co-authors. Ms Kosmaczewski presented all needed statements of contributions signed by the co-authors. According to the statements, Ms Kosmaczewski performed ~50% (two co-authors didn't provide the information about their contribution in percentages) of the work for this paper. According to the ADS NASA platform, this publication has been cited eight times.

In this work, Ms Kosmaczewski analysed the mid-infrared properties of the most compact, spectroscopically confirmed radio sources to study the relative contribution from different parts of AGN and ISM to the observed infrared, X-ray and γ-ray emission. Selected 29 young radio galaxies were detected in XMM-Newton or Chandra X-ray Observatory and were observed in the WISE, IRAS and Spitzer telescopes. The main findings of this article are the relation between the jet duty cycle and the ongoing star formation and the fact that sources for which the MIR radiation is dominated by the ISM uniformly populate the region occupied by galaxies with a wide range of noticeable star formation activity.

Chapter 3 is based on the paper published in the Astrophysical Jurnal in 2022, "Spectroscopic Diagnostics of the Mid-infrared Features of the Dark Globule DC 314.8-5.1 with the Spitzer Space Telescope" (hereafter **Paper II**), written by Kosmaczewski, Stawarz, Rocha, Shenoy, and Karska. According to the statements, Ms Kosmaczewski performed ~70% (one co-author didn't provide the information about his contribution in percentages) of the work for this paper.

In this article, the authors performed a detailed analysis of the system DC 314.8-5.1. This system is a quiescent cloud, and according to the literature, is suspected to be just prior to the onset of low-mass star formation. Mid-infrared properties of the eastern edge of this region were discussed based on the lower-resolution IRS Spitzer spectra in the range of 5-25 μm. This region is particularly interesting due to its close association with a B-type field star,

which makes the spatial analysis more precise. Ms Kosmaczewski analyzed the PAH emission features, which are the main tracer of the ISM, using spectra modelling. The authors found that the intensities of PAH features decrease with the distance from the ionizing B-type star towards the cloud centre but not with the same distance scale. It can be explained as the ionization of the cloud core by cosmic radiation together with photo-ionization by the surrounding star. Obtained results suggest divergent physical conditions as compared to molecular clouds with ongoing star formation. The authors summarize that pre-starforming globules have differing conditions from their later evolutionary stages. This finding makes pre-starforming globules an interesting source for study, which was done in the following chapter (submitted article).

Chapter 4 is based on the paper submitted to the Astrophysical Jurnal in September 2022, "Multiwavelength Survey of Dark Globule DC 314.8-5.1: Point Source Identification and Diffuse Emission Characterization" (hereafter **Paper III**), written by Kosmaczewski, Stawarz, Cheung, Bamba, Karska and Rocha. The article is not accepted yet, and it isn't easy to estimate the final contribution of the first author to the paper.
This article is a natural follow-up of **Paper II**, in which additional multi-wavelength data (from X-ray to far infrared) were included in the detailed analysis of the DC 314.8-5.1 system. This analysis mainly aimed to identify potential protostars and young stellar objects associated with the cloud. The detailed analysis of the multi-wavelength data did not reveal any sources of this type, confirming the very early evolutionary stage of the system. To summarize, DC 314.8-5.1 represents a dense and compact reservoir of cold dust and gas, which provides a unique opportunity to gain insight into the primordial form of the interstellar medium. The analysis showed that the system, characterized by the dominant temperature of 14 K (gas), also includes an additional component of 200K (hot gas).

The final summary and future perspectives are presented in a short **Chapter 5** of the dissertation.

Referee's comments

1. In my impression, there is a missing part of the introduction in which Ms Kosmaczewski could tell the story of how the following articles are connected. I found this part in Chapter 5 already after reading all articles. I think a short description should also be given just before Chapter 2. I would expect a kind of

storytelling to show how different papers are connected and how they build a homogenous whole before reading them. I was also missing the definition of the main problem/question on which the dissertation focuses.

2. **Paper I** – is it possible that the blending of WISE-detected sources can influence the classification and the final summary? Also, WISE 3.4 (and similarly other WISE bands) detects radiation at λ=3.4 μm of a galaxy at z = 0.01, but λ=6.8 μm for a galaxy at z=0.99. It means that they probe redshifted radiation. Does it influence the homogeneous comparison of WISE colours (e.g. Fig. 2.2) ? Can it also be related to a better agreement with Asmus et al. 2015 for objects with z<0.4?
3. **Paper II**:
    1. Can Ms Kosmaczewski discuss the influence of the estimated extinction of the eastern part of DC 314.8-5.1 for the results? For my curiosity, what if the estimated extinction is 10% larger? Would it change the final results or influence the possibility of having water ice in 5-7 micron features?
    2. The figure 3.9 shows the zoom-in for the spectral fit of one of the regions. I wonder if it is possible that on the left upper panel, for wavelenghts range 5.7~6 um, are located two additional peaks which are not taken into account for the spectral fit. Can Ms Kosmaczewski elaborate on the possible origin of these data points?
4. **Paper III**: rather my curiosity than a comment. Using existing instruments, which kind of observation should be taken to make a final proof that DC 314.8-5.1 has no pre-main sequence stars? I understand that Swift XRT instrument is not deep enough to detect faintest objects.
5. **Papers II & III**: those two papers show a detailed analysis of the DC 314.8-5.1 system from the mid-infrared spectra and the multi-wavelength analysis. Is this system missing any other investigation, or does Ms Kosmaczewski's work exhausts all known studies on this specific dark cloud?

The comments presented above do not diminish the value of the work of Ms Koszmaczewski. The work reported in this PhD dissertation is of very high quality and represents a significant progress in the understanding of cosmic dust on various astrophysical scale in a broad range of wavelenghts. The text is very well documented, with a large corpus of references. The disertation, which composes of the two published and one submitted article, is pleasant to read and well written. Presented Introduction, as well as published

articles, undoubtedly shows that Ms Kosmaczewski has good and solid knowledge in the area of multi-wavelenght diagnostic cosmic dust.

Summing up, **I consider the doctoral thesis of Ms Emily Lynette Kosmaczewski to be a valuable contribution and to meet the criteria prescribed by the law for a doctoral dissertation. Therefore, I request that this dissertation be admitted to public defense.**

I would also like to nominate the dissertation of Ms Kosmaczewki for distinction. Her publication achievements (two papers published already in the Astrophysical Journal, and the third one submitted) as well as the valuable contribution to the subject of comic dust are worth to be recognized.

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