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Review of the work presented by Ambra Nanni to obtain her habilitation degree

I have no personal connections with Dr Ambra Nanni and my review is based on the documentation she presented and the articles she published.

The eight articles, which she grouped under the title "Investigating the build-up of dust in galaxies" were published between 2016 and 2020. They are a natural extension of two of the papers presented in her thesis:
Nanni, A., Bressan, A., Marigo P., Girardi, L., 2013, MNRAS, 434, 2390: Evolution of thermally pulsing asymptotic giant branch stars II. Dust production at varying metallicity,
and
Nanni, A., Bressan, A., Marigo, P., Girardi, L., 2014, MNRAS, 438, 2328: Evolution of thermally pulsing asymptotic giant branch stars. III. Dust production at supersolar metallicities.

Since 2020, she published six more papers in which she is one of the leading authors.

During her thesis, under the leadership of Alberto Bressan and with the participation of Paola Margo and Leo Girardi, who are leading experts of the theory of intermediate-mass stars, Ambra Nanni modelled the dust formation and growth for the models of thermally pulsating asymptotic giant branch (TP-AGB) stars computed with the COLIBRI code (Marigo et al. 2013). The aim was to compute the basic quantities needed for stellar population studies in the MIR as a function of stellar parameters in order to allow a correct interpretation of galaxy spectra, in which dust is a critical element. These works served as a basis to the papers presented by Ambra Nanni to apply for her habilitation.

1- In the first of these papers, Nanni et al 2016 (H5), using their dust growth model, compute stellar spectra and colours and compare them with observations of C-stars in the Small Magellanic Cloud. Such comparison is a good way to validate the results of dust growth scheme and of the underlying TP-AGB models and to assert which choices of optical properties and grain size lead to a correct fit with the observations in the near- and mid-infrared (NIR and MIR). To obtain these colours, Ambra Nanni coupled their dust growth model with radiative transfer calculations performed with the code MoD (Groenewegen 2012), based on the code DUSTY (Ivezic & Elitzur 1997). They find that the complete set of observed NIR and MIR colours are best reproduced by small grains (sizes between ~0.035 and ~0.12 μm).

2- In a following paper, Nanni et al. 2018 (H3), the authors estimated the mass-loss rate and dust production rate of the *entire* population of C-stars (~3000 stars) in the Small Magellanic Cloud (SMC). They used the newly computed grids of spectra reprocessed by dust from paper H5. For the first time, the grids of spectra were computed as a function of the main stellar parameters using a consistent, physically based model of dust growth coupled with wind outflow. The presented models used selected combinations of optical constants and grain sizes that have been shown to reproduce simultaneously the most relevant colour-colour diagrams in the SMC in paper H5. With their grids of models, they fit the spectral energy distributions of all the C-stars in the SMC, and derive in a consistent way parameters such as stellar luminosities, mass-loss rates, gas-to-dust ratios, expansion velocities and dust chemistry. The dust production rate of carbon stars in the SMC obtained by this method was found to be different from the ones in the literature by factors 2-5.

3- In Nanni, A., 2019 (H4), Ambra Nanni further constrained the combinations of optical constants and grain size of carbon dust selected in paper 5 [H5] by comparing the predictions and observations of a combination of optical Gaia DR2 and 2MASS data.

4- A similar work to H3, Nanni et al. 2019 (H4) estimated the total dust production rate in the Large Magellanic Cloud from about 8000 C-stars and found a dust production rate 7 times larger than in the SMC.

5- The Burgarella, Nanni et al. 2020 (H2) paper, in which A.N. contributed only 30%, can actually be considered as a preliminary to paper H1 in the process of evolution of Ambra Nanni's achievements. It fits the spectral energy distributions (SEDs) of distant galaxies (redshifts between 5 and 10) with the code CIGALE (Burgarella et al. 2005; Boquien et al. 2019) to obtain their star formation histories and their dust content. The fitting process by CIGALE is described in detail in this paper. The calculation of the metal and dust evolution, performed by Ambra Nanni, is fully described in the next paper.

6- The Nanni, Burgarella et al. 2020 (H1) paper investigated the gas, metal, and dust evolution in low-metallicity local and high-redshift galaxies by considering the evolution of metals and dust and computing the resulting spectral energy distribution to be compared to IR, optical and UV observational data. The main goal was to to reproduce the observed properties of high-redshift galaxies, in particular the peak in dust mass over total stellar mass (sMdust) observed within a few hundred million years, and the decrease in sMdust at a later time. The study of local galaxies, for which the metallicity and gas fraction are known, was necessary to constrain the physical processes driving the evolution of baryons to be applied at high redshift. The development of the physical prescriptions for metal and dust evolution was entirely performed by Ambra Nanni. The chemical enrichment of the galaxies was computed by means of the OMEGA code (Côté et al. 2017). Dust is formed in supernovae remnants, around evolved low-mass stars and is composed predominantly of silicates, amorphous carbon and metallic iron. The physical processes changing the mass of dust as a function of time are: outflows, dust destruction from SN shock waves propagating in the ISM, and dust growth in the ISM. All these processes were included to obtain the SEDs predicted by CIGALE. It was found that the observations require an initial stellar mass function rich in massive stars. In such conditions, dust enrichment from TP-AGB stars and from Type Ia SNe plays a minor role. Galactic outflows are essential to reproduce the decline of the sMdust.

These six publications demonstrate a remarkable evolution of the research work of Ambra Nanni from a study of the formation and growth of dust grains towards study of the evolution of dust and metals in galaxies up to the highest redshifts. These publications led to 3 catalogues and other public scientific products such as https://ambrananni085.wixsite.com/ambrananni/online-data-1 and https://ambrananni085.wixsite.com/ambrananni/online- data- 1).

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The two remaining papers which A. Nanni added to her curriculum and in which she is one of the leading authors are related to dust in C-stars. They make use of previous results achieved by her on the topic and have impacts in other fields of astronomy.

7- In Groenewegen, Nanni, et. al 2020 (H7), the authors study the bolometric magnitude-period relation relation in dust-enshrouded C-stars. The SED-fitting of 247 C-stars was performed using the public grids of spectra reprocessed by dust computed by A. Nanni (H4).

8- In Cristallo, Nanni et al 2020 (H8) a Milky Way chemo-dynamical model was employed to follow the evolution of the SiC dust in C-stars in order to understand the origin of presolar SiC in the Solar System.

More recent works by Ambra Nanni, published from the National Centre for Nuclear Research and not included in the Cycle of scientific articles under the name "Investigating the build-up of dust in galaxies" that she presented, are

9- Romano, Nanni et al 2023: Star-formation-driven outflows in local dwarf galaxies as revealed from [CII] observations by Herschel,

10- Donevski, Damjanov, Nanni et al 2023: In pursuit of giants- II. Evolution of dusty quiescent galaxies over the last six billion years from the hCOSMOS survey

11- Nanni, Cristallo et al 2023: Dust survival in harsh environments. Is photo-evaporation an important destruction mechanism?

Many other works have been recently submitted.

The works of Ambra Nanni are fully recognized internationally as can be judged by her quotation rates (131 and 64 quotes respectively for the first two papers, 30 for each of the papers published in 2020) and by the number of invited talks and reviews (9).

Ambra Nanni participates in many international research teams and is co-editor of the AGB newsletter since 2014 (https://www.astro.keele.ac.uk/AGBnews/).

She is already supervising one postdoc (Michael Romano) and one PhD student (Prasad Sawant) and co-supervising two other PhD students (Gabriele Riccio and Mahmoud Hamed).

Apart from tasks related to research and teaching, Ambra Nanni also takes part in outreach initiatives for science communication to the general public: 2 presentations for the general public at European researchers' night, 3 live interviews on social networks, 1 commemorative event and 2 initiatives for middle and high school students.

Conclusion

In view of the above, I consider that the scientific achievements and activities of Ambra Nanni fully meet the requirements for habilitation in the domain of Astronomy.

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