Astronomy in Focus - XXX
Proceedings IAU Symposium No. XXX, 2018
M. T. Lago, ed.

doi:10.1017/S1743921319004708

Nano dust in stellar atmospheres and winds

Susanne Höfner

Department of Physics & Astronomy, Uppsala University, Sweden
email: susanne.hoefner@physics.uu.se

The extended dynamical atmospheres of cool, luminous asymptotic giant branch stars (AGB stars), are places where solid particles condense out of the gas. This stardust leaves its marks on the observable stellar spectra, and also on the structure and dynamics of the stellar atmospheres, since radiation pressure on the newly-formed grains is a key factor for driving the massive winds of these evolved low- and intermediate mass stars. The mass loss of AGB stars is discussed in detail in a review by Höfner & Olofsson (2018). In recent years, considerable progress has been made in understanding the underlying physical processes, and in characterizing the properties of the dust particles. In particular, improvements in high-angular-resolution techniques have led to spatially resolved observations of the dust-forming atmospheric layers of close-by cool giant stars, making detailed comparisons with predictive models possible. Mg-Fe silicates and Al_2O_3 are prominent dust species in mid-IR spectra of M-type AGB stars; interferometric measurements indicate that alumina form closer to the star than silicates (e.g., Karovicova *et al.* 2013). Large dust grains (0.1–0.5 μm) are found at distances of about 2 stellar radii, e.g. Norris *et al.* (2012); Ohnaka *et al.* (2017), as required for driving winds by photon scattering on near-transparent silicate grains with a low Fe/Mg ratio. RHD models of winds driven by photon scattering on Mg_2SiO_4 grains with sizes of $0.1 - 1\,\mu$m show realistic mass loss rates and wind velocities, as well as visual and near-IR photometry in good agreement with observations, see Höfner (2008); Bladh *et al.* (2013). The formation of composite grains with an Al_2O_3 core and a silicate mantle can give grain growth a head start, leading to higher mass loss rates and wind velocities, and an even better agreement with observed variations in visual and near-IR colors, cf. Höfner *et al.* (2016). High-angular-resolution imaging of scattered visual and near-IR light shows clumpy dust clouds surrounding AGB stars; cloud morphologies and grain sizes change on time scales of weeks to months, e.g. Khouri *et al.* (2016), Ohnaka *et al.* (2017). Clumpy dust clouds emerge naturally in 3D RHD star-in-a-box models, as a consequence of atmospheric shock waves induced by giant convection cells, see Freytag & Höfner (2008), Freytag *et al.* (2017), Höfner & Freytag (in prep.).

References

Bladh, S., Höfner, S., Aringer, B., & Eriksson, K. 2015, *A&A*, 575, A105
Bladh, S., Höfner, S., Nowotny, W., Aringer, B., & Eriksson, K. 2013, *A&A*, 553, A20
Freytag, B., & Höfner, S. 2008, *A&A*, 483, 571
Freytag, B., Liljegren, S., & Höfner, S. 2017, *A&A*, 600, A137
Höfner, S. 2008, *A&A*, 491, L1
Höfner, S., Bladh, S., Aringer, B., & Ahuja, R. 2016, *A&A*, 594, A108
Höfner, S. & Olofsson, H. 2018, *A&ARv*, 26:1
Karovicova, I., Wittkowski, M., Ohnaka, K., *et al.* 2013, *A&A*, 560, A75
Khouri, T., Maercker, M., Waters, L. B. F. M., *et al.* 2016, *A&A*, 591, A70
Norris, B. R. M., Tuthill, P. G., Ireland, M. J., *et al.* 2012, *Nature*, 484, 220
Ohnaka, K., Weigelt, G., & Hofmann, K.-H. 2017, *A&A*, 597, A20