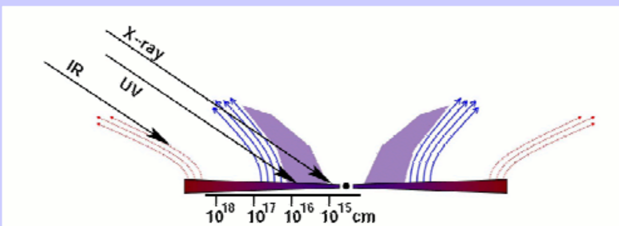
Crystalline silicates, corundum and periclase in the wind of quasar PG 2112 +059

Ciska Markwick-Kemper (University of Manchester)

Sarah Gallagher (UCLA)

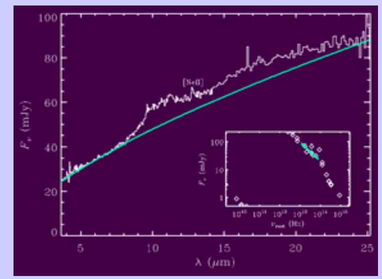
Dean C. Hines (Space Science Institute)

Jeroen Bouwman (MPIA Heidelberg)



Left Diagram of the accretion disk and wind with the supermassive black hole in the middle. The red dotted curves indicate the relatively cool and slow moving dust forming wind. The line of sight towards the IR continuum emission from the disk (arrow) does not pass through the dusty wind, and hence the dust features can be seen in emission. (Figure from Gallagher & Everett 2007)

Right Spitzer spectroscopy of quasar PG 2112+059 (white line; rest wavelength), showing that broad infrared resonances due to dust are detected on top of a continuum (cyan line). The location of the [NeII] transition is indicated.



Elvis, M., Marengo, M. & Karovska, M., 2002, ApJL 567, 107

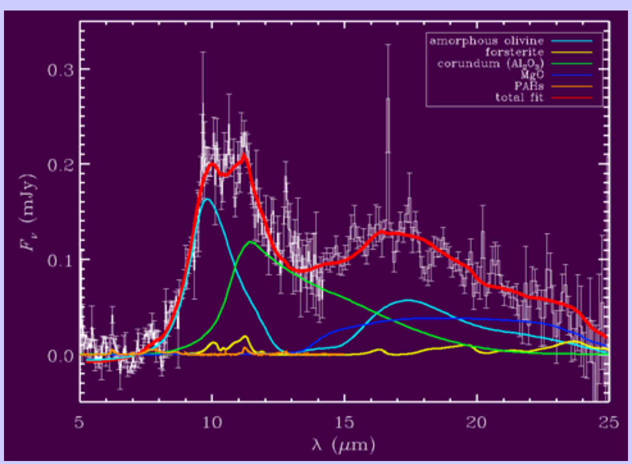
Gallagher, S.C. & Everett, J. E., 2007, astro-ph/0701076

Hao, L. et al. 2005, ApJL 625, 75

Priddey, R. S. et al. 2003, MNRAS 344, L74

Sturm, E. et al. 2005, ApJL 629, 21

Below A least χ^2 fit over the 8-25 μm wavelength range, showing the relative contributions due to the amorphous silicate $Mg_{2(1-x)}Fe_{2x}SiO_4$, the crystalline silicate forsterite (Mg_2SiO_4), corundum (Al_2O_3), periclase (MgO) and polycyclic aromatic hydrocarbons (PAHs). The PAHs form only a minor contribution to the 11.2 micron feature; most of it is due to crystalline forsterite.



Dust in the local Universe The main dust producers in our own Galaxy are Asymptotic Giant Branch (AGB) stars, which are post-main-sequence stars with initial masses of 1-8 $M_\odot$. During the mass loss phase conditions in the stellar wind are favorable for the formation of dust. The precise composition and lattice structure, as well as the grain size and shape, depend strongly on the physical conditions in the stellar winds, and vary from source to source.

Dust in the high-redshift Universe Quasar host galaxies at $z \approx 6$ have been found to contain a significant amount of dust ($10^8 - 10^9\ M_\odot$; Priddey et al. 2003) at a time that the Universe was still too young to contain AGB stars, as it takes their progenitors about 1 Gyr to evolve off the main-sequence. Thus, an additional source of dust production is required. Elvis et al. (2002) explored the possibility that quasar winds might provide the conditions needed for dust formation. Indeed, it was found that a dust formation window likely exists in the quasar winds, in which conditions are comparable to those in AGB stellar outflows.

Dust formation in quasar winds has been seen towards several quasars (e.g. Hao et al. 2005). The accretion disk surrounding the black hole in the center of the quasar host galaxy is believed to develop a stratified wind, where the conditions suitable for dust formation are found at the largest radii (Gallagher & Everett 2007). Seen under the typical quasar viewing angle, these dusty winds do not pass in front of the infrared continuum originating from the disk, and dust emission features may form. Indeed, infrared emission features of silicate dust, with a temperature of ~200 K, have been seen towards quasars (Hao et al. 2005, Sturm et al. 2005).

Dust composition By mass, the following components are present: Mg-rich silicates (58.6%), Al_2O_3 (corundum; 38%) and MgO (periclase; 3%). Of the silicates, approximately 5% is crystalline. The coexistence of these species – which all form at different temperatures – suggests that the dust condensation sequence truncates at different points, pointing towards an inhomogeneous density and temperature distribution.