The lifetimes of protoplanetary gas and dust disks

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The lifetimes of the gas and the dust in protoplanetary disks are different because of the different governing mechanisms of their evolution. We estimate the lifetimes of the gas and dust disks under the following assumptions.

The gas disk evolution occurs through its viscosity, and we adopt the so-called alpha model with alpha=10^(-3). Extreme ultraviolet (EUV) radiation of the central star also induces evaporation of the gas. The amount of the EUV flux depends on the mass of the star. We assume that T Tauri stars emit EUV with a magnitude that can evaporates the gas in 10^7 years, and that the EUV flux of Herbig Ae/Be stars is so large as to evaporate the gas within 10^6 years. Under the above assumptions, the gas inside 10AU disappears first due to the EUV from the star, and a gas ring remains. Then, the inner hole expands.

The main composition of the dust disk is assumed to be millimeter sized grains as suggested by radio observations. Such grains accrete onto the star due to the gas drag with a timescale of 10^6 years and this timescale is independent of the mass of the star. The dust disk disappears from the outside.

The above model of the gas and dust disks suggests that the morphology of protoplanetary disks of 10^7 years largely depends on the EUV flux of the central star (and the mass of the star). Gas rings with little dust remain around T Tauri stars, because the lifetime of the gas disk is much larger than that of the dust. On the other hand, for Herbig Ae/Be stars, the lifetime of the gas disk is shorter than the dust, leading to remnant dust rings with little gas. We predict existence of gas rings around low mass stars of age ~10^7 years, which could not be detected by observations of dust emission. Discovery of such gas rings would support the hypothetical mechanism of the gas evaporation by the stellar EUV radiation.