NO CIRCUMSTELLAR DISK AROUND 68 OPHIUCHI?

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Observations with the Bernard Lyot 2-m telescope at the Pic du Midi Observatory on 1992 Aug. 26 revealed a disk-like structure around the nearby main-sequence star 68 Ophiuchi (HR 6723, type A2 Vn, distance 48 pc, m_v=4.45). The observations were done in the 695-nm band with an anti-blooming CCD camera. The disk was viewed nearly edge-on, and inclined by 13^o to the east of north (IAU Circular 5795). 68 Oph is known as a member of a double system whose companion is a 6.9-magnitude star with a separation of 0"66 in p.a.$\sim$ 111.5^o.

Although we were always very cautious about our first results, 68 Oph was the only star, out of eleven reduced in the same way, which showed a possible disk. Due to the high S/N ratio (30 sigma at 3" from the star) and to the remarkable similarity with the β Pictoris disk (Lecavelier des Etangs et al. 1993, *Astronomy and Astrophysics*, **274**, 877), the detection seemed to be quite convincing. Furthermore, 68 Oph presents a strong polarization; and, although it is difficult to estimate the infrared emission of the redder companion, a slight infrared excess is present in the IRAS Faint Source Catalogue.

Several confirmations were attempted. None succeeded; however, they never reached the detection limit necessary to definitely exclude the disk.

Meanwhile, we have also searched for a possible artificial origin of the detected disk. Numerical artifacts in the course of the data reduction process have been thoroughly investigated. In order to localize the faint companion with respect to the main component, new images of the binary system were obtained at the Pic du Midi Observatory, (J.Lecacheux, private communication). Then, we evaluate the numerical contamination due to the diffuse light of the companion. It turns out that the existence of this faint secondary component of 68 Oph, could in fact induce an elongation of the image perpendicular to the major axis (exactly the direction in which the disk was first detected while ignoring the companion location), roughly resembling the detected disk, after correcting for diffuse light through a template star with no companion. We thus recommend other observations to finally clarify the situation about the 68 Oph circumstellar disk.

Fireworks around Naked T Tauri Stars

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Our investigations have revealed new possibilities for searches and observations of circumstellar protoplanetary disks at the intermediate stages of planet formation in addition to strategies of discovery and investigation of protoplanetary gas–dust disks and other planetary systems. According to our estimates, high-energy collisions of large 100–1000 km bodies take place in disks similar to the early circumsolar disk at the stage of planet formation with protoplanet masses more than 0.1 the mass of the Earth. Such collisions are attended by explosive processes with energy in the range $30 < \log(E/\mathrm{erg}) < 35$.

The result of the collision of two bodies depends on the impact energy. If the impact energy is sufficient, not only for disruption of the bodies, but also for other dissipative losses, heating, melting and partial evaporation of the matter take place. It was pointed out earlier by a number of authors that the high-temperature (up to 10000 K) gas jets can be formed at the high-velocity collisions. This effect is of importance to the evaluation of the luminosity fluctuations in the optical, IR and radio ranges.

The generalized Boltzmann equation with the modified Smoluchowski operator is sufficient to find the function of distribution $n(m, v, x, t)$ and to obtain simple relations for intermediate asymptotics in the mass and velocity spectra, which are necessary to make the resulting estimates of the frequency and amplitude of the luminosity fluctuations.

For the collisions in the vicinity of a star possessing a disk with a mass of about 0.1 solar masses, the duration of individual flashes are in the range from tens of minutes to several hours and their frequency is in the interval from thousands per year for the events with Jupiter's luminosity to one per year for the events with luminosity about 1000 times higher. Such phenomena—named by us "fireworks"—take place in the vicinity of young stars previously possessing gas–dust disks.

Modified Smoluchowski Operator and Mass-Spectrum of Protoplanets

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The classic Smoluchowski equation is valid only in the thermodynamic limit, when a number of the particles N in the volume V is great, so that the concentration of particles $n = N/V$ is finite. However, during coagulation n can become as small as one likes. Formal application of the Smoluchowski equation to the case of small values of n leads to the difficulties. They lie in the fact that its steady-state solution is identical with zero and all the moments, beginning from the second one, diverge. It is due to an unlimited and definite positive quadratic form (n, An), where A is the kernel of the Smoluchowski integral operator.

We derived the generalized equation of coagulation which differed from the Smoluchowski one by the presence of the renormalization function $f = [1 - 1/N + g(m, m')]$. Here m and m' are masses of two coagulating particles and $g(m, m'))$ is the pair correlation function. In this case the renormalized kernel is not positive definite and the equation has the stable steady-state non-zero solution and has the finite moments. The relaxation goes on to this solution according to the exponential law at the final stage. The generalized equation of coagulation makes it possible to describe the most interesting stage of relaxation.

We have found the intermediate asymptotic solution in the form of the inverse power law with index $q = 1 + p/2$ for coagulation kernel $A = a(x + x')$, where x is mass m to the power p. It is well known that the largest bodies have, on average, smaller eccentricities and inclinations. So in the region of mass m far more than the mean mass, the effective values of p are smaller than the commonly used 4/3. In other words the mass-spectrum of the largest bodies is steeper and (in the absence of gas accretion) is determined by the surface density distribution of solid material. Our results showed that collisions of large bodies in forming planetary systems are more frequent and more energetic than previously assumed.

Spectral Evolution of Protoplanetary Disks

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We have studied the energy distribution of objects in an IRAS-selected sample of early-type stars with infrared excesses due to circumstellar dust. The studied stars are young BAF stars with Hα emission. Some are embedded, but most are isolated. Presumably we have detected a population intermediate between the youngest Herbig Ae/Be stars and the Beta Pictoris Stars. Interestingly, more than half of the well studied objects show a double-peaked energy distribution, with a deficit of flux at 5–10 μm, i.e. in the temperature range where ices form. We conjecture that the decrease of the mid-IR excess before that of the near-IR excess is due to the formation of larger bodies.

TIMESCALES FOR THE DISSIPATION OF THE DUSTY AND GASEOUS COMPONENTS OF CIRCUMSTELLAR (PROTOPLANETARY?) DISKS

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The time over which the circumstellar disks of low mass pre-main sequence stars dissipate is likely related to the timescale for proto-planetary accumulation. The dissipation timescale for warm dust may represent the time over which grains in the inner disk accumulate into larger bodies which radiate inefficiently in the infra-red. Available data suggest that this timescale is short ($\lesssim 3\times10^5$ years), and that the dissipation occurs nearly simultaneously over the entire inner disk ($\lesssim$ 5 AU). We have obtained near-IR photometry and re-analyzed IRAS observations of low mass pre-main sequence stars in the Taurus-Auriga association in order to refine estimates of the dust disk dissipation timescale. Eight of 32 X-ray selected stars do appear as sources in IRAS ADDSCANs. Of these, three are misidentifications of objects at the same scan angle, but with different ecliptic longitudes. Two are stars with previously known near-IR excesses. Only 3 may be stars with inner holes, caught in the act of losing their disks. Considering only the stars with ages less than about 6 Myr, and correcting for X-ray incompleteness, we estimate a dissipation time of 8×10^4 years, albeit with considerable uncertainty.

For normal gas-to-dust ratios, the dust constitutes only about 1% of the material in the circumstellar disk, but there are few data relevant to the dissipation timescales for the gas disks. We expect the gas disks to survive longer than the dust disks, and require it if we are to form giant planets. It is feasible to detect fluorescently-excited Lyman-band emission of molecular hydrogen (H_2) from the inner $\sim$20 R_* of the gas disk. Recent HST/GHRS observations of 6 classical T Tauri stars with a wide range in activity levels have in fact revealed weak H_2 emission in the Lyman band P(5) 1562.4-Å transition. Line fluxes range from 2 to 20×10^{-15} $ergs\ cm^{-2}\ s^{-1}$. The data are not of sufficient quality for us to determine unambiguously whether the emission originates in a warm inner disk or in a shock. We are following-up with HST/GHRS observations optimized to search for H_2 in a sample of pre-main sequence stars not known to have dust disks.