SOME THOUGHTS ON THE VEGA PARTICULATE SHELL. A. W. Harris, Jet Propulsion Laboratory, Pasadena, CA, 91109.

The IR excess observed around Vega by IRAS has been modeled as a shell of particles $\gtrsim$1 mm in size orbiting Vega at a radius of ~85 AU, radiating with an apparent black body spectrum at ~85 K. The optical thickness of this "shell" is $\tau \sim 2.5 \times 10^{-5}$ (1).

The interpretation which seems almost inescapable is that this shell represents the remnant of a circumstellar disk, from which planets mah also have formed. I suggest that the present disk is collisionally evolved to a quasi-steady state. The timescale of collisions between particles is $t \sim (\tau\Omega)^{-1}$, where Ω is the orbit frequency. The present particle size is much larger than any known source of interstellar grains, suggesting growth by coagulation. As the mean particle size increases, τ decreases, thus t increases and further growth slows. In the present cloud, $t \sim 3 \times 10^6$ years, which is somewhat shorter than the expected age of Vega (10^{7-8} years), thus it is plausibly a collisionslly relaxed disk. If fragmentation is the dominant process at present, a similar end state is reached, since an excess of large particles will be broken down until they are removed by Poynting-Robertson drag, leaving a remnant population with a collision lifetime comparable to the age of the cloud.

I have modeled the Vega cloud as a disk of particles satisfying the condition $t = (\tau\Omega)^{-1}$ = constant at all orbital radii, r. Since $\Omega \propto r^{-3/2}$, the cloud becomes thicker at larger radii. The effective emitting area, as a function of equilibrium black body temperature T is:

$$dA \propto \frac{dT}{T^8}$$

Hence even allowing for the T^4 dependance of black body emission, most of the energy is radiated from the outer edge of the cloud by material near the lower temperature limit. It is thus necessary to impose a lower temperature limit in the model, with a corresponding outer limit to the disk radius. The observed IR excesses at 25, 60, and 100 μm can be matched by a disk of outer radius ~150 AU and temperature at that radius of 63 K, with the areal temperature profile given above. The density of the disk is characterized by a collision time scale $t = (\tau\Omega)^{-1} = 3 \times 10^6$ years. This model disk is observationally indistinguishable from the shell model of constant temperature (1). The predicted flux at 12 μm is 0.1 Jy, an order of magnitude above that of the constant temperature model, but still an order of magnitude below the observational limit. The collision timescale for an inner particulate cloud dense enough to "see" at 12 μm would thus be less than 3×10^5 years.

An important corollary of this model is that the mass of the cloud is not observationally constrained. Nature will contrive to conceal whatever mass is available in whatever size bodies are necessary to yield the requisite value of τ. Thus the total mass of the cloud is constrained only by a lower limit, corresponding

to all particles as small as possible. It might be noted in this matter that the lower limit to the particle size (1) may not be firm, since the population of smaller particles may be resupplied by collisional erosion of the larger particles or by inward evolution from farther out by Poynting Robertson drag. Thus the smallest particles (which likely dominate the areal distribution) may be even an order of magnitude smaller, and the total mass of the cloud may be only a tiny fraction of an earth mass.

REFERENCES

1. Aumann, H. H., Gillett, F. C., Beichman, C. A., de Jong, T., Houck, J. R., Low, F., Neugebauer, G., Walker, R. G., and Wesselius, P. (1984) Astrophys. J. Lett., in press.