This equation only gives us the local response of the disk to these perturbations, and we see that the α r-dependence plays no role, the major role being locally played by the parameter dependence. When we look for the global response of the disk, this equation no longer applies, being substituted by the correct and more complicated set of coupled differential equations, which solution is highly dependent on the α radial dependence.

References: [1] Cannizzo J. K. et al. (1982) in *Pulsations in Classical and Cataclysmic Variables* (J. P. Cox and C. J. Hanson, eds.), Univ. of Colorado, Boulder. [2] Lin D. N. C. and Taam R. E. (1984) in *High Energy Transients in Astrophysics* (S. E. Woosley, ed.), AIP Conf. Proc. 115, 83, New York. [3] Huang M. and Wheeler J. C. (1989) *Astrophys. J., 343*, 229. [4] Mineshige S. and Wheeler J. C. (1989) *Astrophys. J., 343*, 241. [5] Hameury J. M. et al. (1986) *Astron. Astrophys., 162*, 71. [6] Hameury J. M. et al. (1988) *Astron. Astrophys., 192*, 187. [7] Hameury J. M. et al. (1990) *Astrophys. J., 353*, 585.

S14-92 ABS. ONLY N94-31130 971 p.

CONVECTIVE SOLAR NEBULA. C. Meirelles Filho and M. Reyes-Ruiz, Space Physics and Astronomy Department, Rice University, Houston TX 77251, USA.

Analyzing turbulent flows with rotation, Dubrulle and Valdettaro [1] have concluded that some new effects come into play and may modify the standard picture we have about turbulence. In that respect the value of the Rossby number is of crucial importance since it will determine the transition between regimes where rotation is or is not important. With rotation there will be a tendency to constrain the motion to the plane perpendicular to the rotation axis and as a consequence the horizontal scale will increase as compared to the longitudinal one, which means that the turnover time in this direction will increase. The net effect is that the energy cascade down process is hindered by rotation. As a matter of fact, when rotation is present one observes two cascades: An enstrophy (vorticity) cascade from large scales to small scales and an inverse energy cascade from small scales to large scales. Since the first process is not efficient on transporting energy to the dissipation range, what we see is energy storage in the large structures at the expense of the small structures. This kind of behavior has been confirmed experimentally by Jacquin et al. [2], who observed that, with rotation, $L_{hor} \approx R_o^{-\gamma} L_z$, where γ is a parameter that depends on the Reynolds number and measures the influence of rotation on turbulence and R_o is the Rossby number. For a very large γ we obtain, in the inertial range, a spectrum of k^{-3} instead of the usual Kolmogorov's $k^{-5/3}$ spectrum. In reality, when rotation is dominant, energy gets stored in inertial waves that propagate it essentially in the longitudinal direction. In that case, we can no longer assign just one viscosity to the fluid and, what is most important, the concept of viscosity loses its meaning since we no longer have local transport of energy. According to Dubrulle [1], $R_o = 1$ is the borderline between these two scenarios: For $R_o > 1$ turbulence is not affected by rotation, for $R_o < 1$ it will be greatly affected. It is worth mentioning that compressibility effects will also affect turbulence through the generation of waves, shocks, etc. These aspects have been underestimated by Cabot et al. [3] in their application of the theory of large-structure turbulence developed by Canuto and Goldman [4] for the turbulence generated by convective instability, in the sense that no discussion about the behavior of the characteristic scale lengths in the problem under the influence of rotation is made nor the conditions under which there will be local energy dissipation and an effective viscosity can be assigned to the flow. Also, not apparent in their results are effects such as inverse energy cascade with consequent diminishing of the angular momentum transport efficiency or even how the spectrum in the inertial zone, i.e., Kolmogorov's spectrum, is affected by rotation. In a previous paper [5], employing results from [1], we have shown that even for Rossby number >1 turbulence is affected by rotation, but it succeeds in forming smaller structures, as compared to the case without rotation, in such a way as to overcome rotational effects. As far as the efficiency of angular momentum transport is concerned, the value of the viscosity parameter is highly affected, even if the Rossby number is much greater than 1.

Such results, however, were derived considering a hot disk, in which opacity is mainly given by electron scattering. In the present work we have applied the formulation developed in the previous work for the description of the viscous-stage solar nebula. Following Wood and Morfill [6] we have used two piecewise continuous powerlaws that depend only on the temperature, corresponding to regions in which opacity is provided either by water ice grains or silicate and Fe grains. It should be remarked, however, that by taking into account the z-structure of the disk, there will be, no matter the radius, a region close to the surface of the disk, where the lower-temperature opacity law applies. As we go further out, this region approaches the midplane of the disk. In the outer regions, where the temperature is below the ice condensation point, only the lower-temperature law is applicable. The height of the point separating these regions will be crucial in the determination of anisotropy factor and the viscosity parameter as well as in the possible existence of critical parameters for the flow. Although our results are preliminary compared to other results in the literature, the efficiency for angular momentum transport we have obtained is higher. These high values of α may imply that within this formulation the viscous evolutionary stage of the nebula is shorter. Our formulation also implies a minimum accretion rate to ignite convective instabilities. Since the mass of the disk is related to the accretion rate the main implication of this is related to the age of the nebula.

References: [1] Dubrulle B. and Valdettaro L. (1992) *Astron. Astrophys., 263*, 387. [2] Jacquin L. et al. (1990) *J. Fluid Mech., 220*, 1. [3] Cabot W. et al. (1987) *Astrophys. J., 69*, 387. [4] Canuto V. M. and Goldman I. (1984) *Phys. Rev. Lett., 54-05*, 430. [5] Meirelles C. F. et al. (1993) submitted. [6] Wood and Morfill (1988) in *Meteorites in the Early Solar System*, 329–347, Univ. of Arizona.

S15-90 ABS. ONLY N94-31131 992 p. 2

ROTATIONAL EFFECTS IN TURBULENCE DRIVEN BY CONVECTION. C. Meirelles Filho, M. Reyes-Ruiz, and C. Luo, Space Physics and Astronomy Department, Rice University, Houston TX 77251, USA.

We have treated turbulence with rotation in a thin Keplerian disk. Highlighting implicit assumptions already existent in the α model together with a geometrical but physically reasonable deduction of the degrees of freedom of the largest eddies, which is of paramount importance in our formulation, we were able to obtain relations satisfied by parameters of the turbulence, such as turnover