Magnetohydrodynamic instabilities in proto-neutron stars

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We investigate the stability of differentially rotating proto-neutron stars (PNSs) with a realistic configuration of magnetic field, and heat diffusion caused by neutrino radiations. Stability criteria for general MHD instabilities are derived using a local linear analysis. We find that axisymmetric and nonaxisymmetric modes of magnetorotational instability (MRI) grow dynamically in the differentially rotating PNSs. It is also found that, in the case of the rigid rotation, the magnetic buoyancy-type instability can grow easily. The heat diffusion, caused by the neutrino radiation, should play important roles in the growth of these instabilities. These instabilities can grow dynamically even in convectively stable layers if the wavelength of unstable modes are shorter than that of critical value. The nonlinear evolution of such instabilities could amplify the magnetic fields and drive MHD turbulence in PNSs, which may lead to enhancement of the turbulent mixing and the neutrino luminosity.