Magnetorotational instability in weakly ionized plasma-application to the protoplanetary disk

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Magnetorotational instability had been studied for a wide variety of accretion disks as an important candidate for the effective viscosity which transports angular momentum outward in the disk. The behavior of the magnetorotational instability in the linear regime in weakly ionized plasma has been analyzed in the present study to evaluate the possibility that this instability effectively works in the protoplanetary disk. The results of the numerical calculation have shown that the instability is sensitive to the ionization ratio, velocity shear in the disk, neutral gas density, and temperature. Hall effect has large influence in the weakly ionized plasma which positively works for the growth rate in the case that the magnetic field direction is parallel to the rotation vector of the disk and negatively works for the growth rate in the case that the magnetic field direction is opposite to the rotation vector. In the case of the primitive solar nebula, effective instability and the sufficient angular momentum transfer occur in the limited condition that the magnetic field is parallel to the rotation vector of the disk and larger than 10 nT when considering the ionization ratio, temperature, and density expected from the model used in the present study which is based on the alpha-disk model.