§12. Physics of Collapses in Toroidal Helical Plasmas

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The collapse phenomena in toroidal plasmas is an essential subject. The collapses are caused by such the activities that their growth rate changes abruptly [1]. A theoretical model of catastrophic events in toroidal helical plasmas is presented.

The method of dressed test mode is applied to the beta-limiting phenomena. In the system with the magnetic shear and magnetic hill, the stationary turbulent state is obtained [2].

M-mode transition and hysteresis

When shear is strong, $s^2 > G_0$, the short wave length mode is excited [2]. ($G_0 = \beta'_p \Omega'$ is the combination of the pressure gradient and magnetic field gradient.) If the pressure gradient reaches the critical gradient, $G_{0e} + G_{0i} > G_c \simeq s$, the turbulent transport coefficient becomes enhanced by the factor $G_0 \beta_i m_i T_e / m_e T_i$. The back transition occurs at the lower critical gradient G_1.The gradient-flux relation has the cusp-type catastrophe, as is illustrated in Fig.1. This relation predicts a sudden change of growth rate at the critical pressure gradient.

Low-m mode excitation

The low-m mode is destabilized by the anomalous resistivity. In the weak shear case, $s^2 < G_0$, the destabilization of the global mode (through the nonlinear interactions with the back ground turbulence) takes place.

Critical pressure gradient

The criterion for the onset of crash is given as

$$|R\beta'| > (1/R\Omega')\, s \quad \text{for } s > 1$$
$$|R\beta'| > (C/R\Omega')\, s^2 \quad \text{for } s < 1.$$

The criteria for the onset of collapse events are summarized in Fig.2. The criteria for the onset of the collapse, which is presented here, have a similarity to the one which has been obtained in the linear and ideal MHD stability theory. This also explains the coincidence that some linear theories have shown.

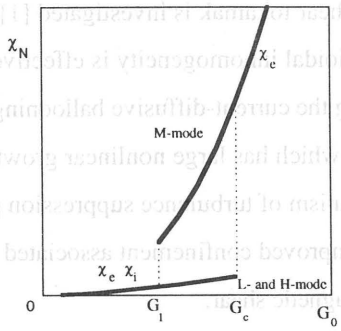

Fig.1 Turbulent transport coefficient as a function of the gradient. Transition is predicted at critical gradient.

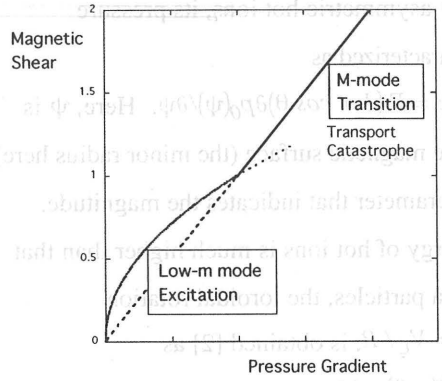

Fig.2 Critical pressure gradient for the onset of collapse events.

References

[1] A review article: S-I Itoh et al., *Plasma Phys. Contr. Fusion* **40** (1998) in press
[2] K. Itoh et al., presented at Toki Conference, 1997.