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EFFECT OF SHEARED FLOW ON RESISTIVE TEARING INSTABILITY AND THE TRIGGERING OF FLARE

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ABSTRACT The nonlinear evolution of tearing modes in the presence of sheared mass flow is studied in the cylindrical geometry. It is demonstrated that a sufficient large sheared mass flow can destabilize the development of resistive tearing instability. It is suggested that the coupling of sheared mass flow with shear magnetic field may be a triggering of solar flares.

1. INTRODUCTION

Magnetic reconnection was first suggested by Dungey (1958) to explain energy release in solar flares and other astrophysical phenomena. It has been shown both analytically (Holfmaan,1975) and numerically (Einaudi, et al.1986; Persson, et al., 1990) that sheared flows could have significant effect on the resistive tearing instability. The investigation of the influence of more general plasma flows on the onset and the evolution of resistive instability has great astrophysical interest, since nonhomogeneous flows are commonly observed in various phenomena believed to involve reconnection, such as solar coronal loops, magnetopause boundary, solar wind, extralatic jets, and fusion experiments.

In this paper, the influence of shear plasma flow along the magnetic field on the resistive tearing instability is investigated in cylindrical geometry.

It is demonstrated that a sufficient large sheared mass flow could destabilize the development of resistive tearing instability and suggested that the coupling of sheared mass flow with the shear magnetic field may be a triggering of solar flares

2. FUNDAMENTAL EQUATIONS AND NUMERICAL METHOD

The nonlinear simulations presented are based on the straight cylinder reduced MHD equations resulting equations (strauss, 1976)

$$\left(\frac{\partial}{\partial t}+\mathbf{V}\cdot\nabla\right)u=\boldsymbol{B}\cdot\nabla J_z+\nu\nabla_{\perp}^2 u, \qquad (1)$$

$$\frac{\partial\psi}{\partial t}=\boldsymbol{B}\cdot\nabla\phi-\eta J_z+E_z, \qquad (2)$$

where ψ and ϕ are z-components of the potential function of

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magnetic field $\mathbf{B}$ and the stream function of plasma velocity $\mathbf{V}$.

The magnetic field equilibrium is given by the parametrization of the safety factor q

$$q(r) = q_0 [1 + r^{2\lambda} [(\frac{q_a}{q_0})^{\lambda} - 1]]^{1/\lambda}$$

In the numerical computation, we use

$$V(r) = r\ G(r) \tag{3}$$

with

$$G(r) = \alpha\ Sech(\frac{r - r_0}{R_v}) \tag{4}$$

where r_o is radii of the singular surface.

In the presence of equilibrium flows, the solution of the basic equations can no longer be symmetric and the ψ and ϕ must be full Fourier series expansion in the poloidal and toroidal directions, instead of the sine and cosine expansion commonly used in the static case, and in this paper we only consider the single helicity, $m/n=2$.

3. NUMERICAL RESULTS

We consider $S=10^4$, $q_o=0.93$, $q_a=4.2$, $\lambda=3.5$,

The time-evolution of normalized growth rate and the dependance of the normalized growth rate γT_r on the shear parameter R_v are shown in Fig.1 and Fig.2 respectively.

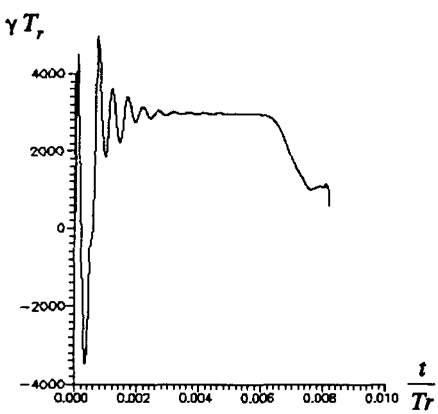

Fig.1 Growth rate vers time.

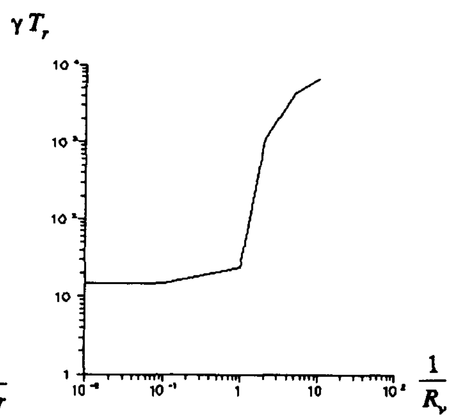

Fig.2 Growth rate vers shear.

For $R_v < 1$, a rapid increase of growth rate toward values typical of the Kelvin-Helmholtz instability was observed and the magnetic island and velocity pattern are distorted by the equilibrium flow, this means a transition form constant ψ to non-constant ψ tearing mode. When R_v is decreased further, the Kelvin-Helmholtz instability is dominant and the presence of a shear magnetic field considerably modifies the properties of the instability.

Fig. 3 shows the normalized island width for the m=2 /n=1 mode with different shear flows.

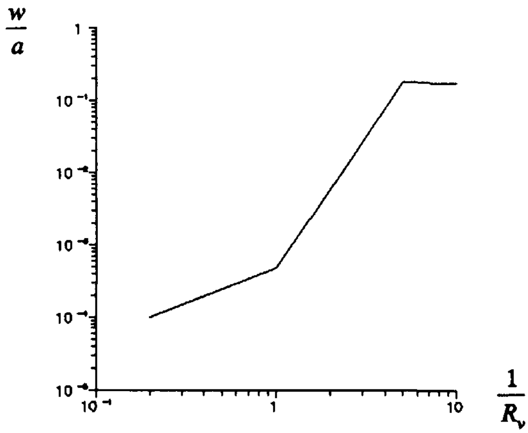

Fig. 3 The normalized island width for (m=2, n=1) mode with different shear parameter R_v.

4. CONCLUSIONS

In this paper, we have explored the dynamics of the flow-driven tearing mode numerically. The results show that the sheared flows could lead to a destabilization of the tearing mode, hence to the formation of magnetic islands in a nonlinear development and ultimately to a rapid release of magnetic energy. The observations show that behavior of the high-velocity prominence plasma is an important key to our understanding of flare trigger, and it is suggested that the coupling of sheared mass flow with shear magnetic field may be a triggering of solar flares, and the results support the observations that the flare trigger may be situated in subphotospheric layer and forms plasma streams propagating upward in to a twisting loop (Vladimir Hayrapetyan, 1992).

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