## References

Bray, R.J., Cram, L.E., Durrant C.J. and Loughhead R.E., 1991, "Plasma Loos in the Solar Corona", Cambridge University Press.

Shibasaki K., 1996, in "Magnetic Reconnection in the Solar Atmosphere", R.D. Bentley and J.T. Mariska (eds.), ASP Conference Series Vol. 111, P. 171.

# Observational Evidences of Ballooning Instability in Solar Flares

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Radio imaging observation of the solar flare on January 2, 1993 showed a formation process of radio sources over the flare loop (Shibasaki, 1996). In the present paper, we interpret this overtopping radio sources as magnetic islands (or balloons) produced by a ballooning instability due to high pressure (or high $\beta$ value) in the flare loop.

The overtopping radio sources appeared several moments in the flare: 1) When a rising plasma cloud hit the apex of the loop, 2) when the growing flare loop reached at its maximum height, and 3) a couple of times after the well developed bright flare loop was formed. At these moments, the plasma $\beta$ value was high, due to local enhancement of the pressure by the collision of the rising plasma cloud with the curved magnetic field at the loop apex 1), and by the collision of the evaporated plasma flow through both legs of the loop at the loop top 2). After the formation of the bright flare loop, the loop was filled with the evaporated high density plasma 3).

Extensive studies have been done of the stability of plasma loops in the solar corona (e.g. Bray et al., 1991). In the field of fusion in magnetically confined plasma such as Tokamak, detailed studies of the stability of the confined plasma have been developed. Main difference between these two cases is line-tying of the solar coronal magnetic fields. They are anchored at the photosphere. Instabilities with low wave numbers (large scale) are suppressed due to line-tying effect. However, instabilities with high wave numbers can develop. Outer boundary of high density ($\beta$) flare loops are unstable against localized interchange instability (ballooning mode) because the outer boundary has unfavorable magnetic field curvature (convex outwards). Appearances of overtopping microwave sources satisfy the above condition of the ballooning instability. The overtopping sources are interpreted as magnetic islands (or balloon) produced by the ballooning instability.

Recent development of numerical simulation made it possible to simulate nonlinear full 3D behavior of the plasma in Tokamak machines under various conditions. The growth of the ballooning mode under high $\beta$ condition was simulated and was compared with the experiment by Park et al.(1995). In the experiment, a strong local pressure bulge destroyed the flux surface and most of the confined plasma escaped. During the disruption, nonthermal emission was observed. Large magnetic islands were formed after the recovery of the magnetic surface. This scenario is very attractive to solar flare scenario, although the physical conditions are very different between the two. It is necessary to do similar MHD simulation (nonlinear, full 3D, resistive) for loops in the corona with high $\beta$. With this scenario, high temperature regions above flare loops, loop top hard X-ray sources and high density plasmoid ejections which were found by YOHKOH could be explained without reconnection above the flare loop.