Current outflow to low-density plasma region of z-pinch with pre-embedded axial magnetic field

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Magnetic flux can be compressed within a conducting shell when the shell collapses by the application of an external force. In z-pinch scheme, the conductor is plasma and it is imploded by the $J \times B$ force due to a large current passed through it, see Fig.1. Compression of magnetic flux and magnetized plasma is gaining interest due to the advances in producing plasmas of high temperature and density for fusion purposes e.g.[1].

In our experiment, we employ a cylindrical configuration, in which an initial axial quasi-static magnetic flux B_{z0} (up to 0.4 T) is pre-embedded in an argon gas column. A high-power electric discharge (300 kA, rise time 1.6 μs) then ionizes the gas and generates an azimuthal magnetic field, creating a pressure that compresses the plasma inward together with the axial magnetic field embedded in it. Non-invasive spectroscopic measurements of the azimuthal magnetic field (B_θ) evolution using recently developed spectroscopic method [2, 3] are presented. Systematic measurements, performed for different initial B_{z0}, show that with increasing initial values of B_{z0}, less current is flowing through the imploding Ar plasma shell. For $B_{z0} = 0.4$ T, only $\sim \frac{1}{4}$ of the current if flowing through the imploding argon plasma whereas most of the current flows at large radii, through a lower-density plasma. We conclude that even in the presence of a low axial magnetic field (relative to the peak azimuthal magnetic-field) this effect is significant. Remarkably, the low-density plasma does not implode under this considerable current, suggesting a formation of a force-free configuration.

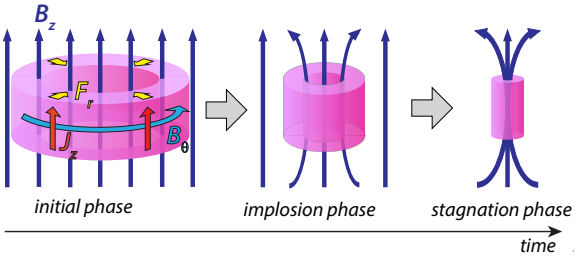

Figure 1: *Principle of magnetic flux compression by z-pinch plasma*

References

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