X-RAY SPECTROSCOPY DIAGNOSTICS TO STUDY COMPLEX SUPERSONIC PLASMA FLOWS WITH ASTROPHYSICAL RELEVANCE IN LASER PLASMA

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Remarkable plasma hydrodynamic phenomena such as supersonic jets and accretion columns have been widely observed in various astrophysical systems. Laboratory experiments employing the plasma produced by high power lasers can be scaled to astrophysical systems by matching dimensionless scaling parameters and thus providing the studies of astrophysical phenomena in controllable conditions. Particularly, laser produced jets are well scalable to that one from young star objects. It was recently shown that the application of external magnetic field to plasma flows allows to investigate stable, large aspect ratio plasma jets. As a sequence, it becomes possible to study the interaction of collimated plasma flows with obstacles or counter streaming flows. Though the hydrodynamics of the plasma is rather complicated there, accretion processes common for binary systems and protostellar disks can be investigated.

The combined X-ray spectroscopy method is developed to determine together electron temperature T_e and density N_e profiles along the initial plasma jet and across the accretion region. In the experiment the plasma jet is initiated by the interaction of 20-60 J 1 ns laser pulses with a bulk CF2 targets and then collimated by 6-20 T poloidal B field. First, the plasma expanding from the laser irradiated target surface is considered as overcooled with non-stationary ionization state, and recombining plasma approach is applied for spectra analysis giving consistent T_e profiles in the range from 100 to 20 eV.

Next, the spectra measured near the obstacle surface provides a clear evidence that at least two distinct fractions of plasmas (hundreds eV "hot" and recombining "cold") with various parameters existed there around the surface. While the cold plasma contribution is considered with recombining plasma approach well describing F He-like series at 40 – 50 eV electron temperatures, the parameters of the hot plasma fraction are determined by steady-state spectra modeling of PrismSPECT code for F Lya satellite structure returning 250-350 eV temperature range. The comparison of Lya line and He-like series intensities provides the estimation on electron density in the shocked accretion zone.

Finally, the obtained parameters and complex spatial configuration of the plasma in accretion zone are used to analyze possible opacity effects on the emitted X-ray spectra in order to understand a systematic discrepancy between mass accretion rates derived from X-ray and optical astronomical observations.