Experimental study of laser plasma expansion in presence of the strong external magnetic field

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We present recent experiments, performed at PEARL laser facility (Institute of Applied Physics), aimed at investigating the dynamic of plasma flows expending into the ambient magnetic field. The main attention has been paid to the case when the plasma flow penetrates across the magnetic field. Such geometry of the experiment is related to laboratory modeling of accretion of matter into compact stars and, especially, to the processes developing at the inner edge of the accretion disks in the region where the pressure of the magnetic field of the star is of the order of the dynamic pressure of the accreting plasma. Using two femtosecond interferometers, 2D snapshots of plasma flow expanding into the ambient magnetic field have been obtained in two geometries (perpendicular and parallel to the direction of the magnetic field lines) and in different times after the plasma flow formation. It has been found that the plasma flow exhibits strong Rayleigh–Taylor instability in the region where the pressure of the magnetic field is of the order of the plasma flow dynamic pressure. As a result of this instability, the plasma flow deeply penetrates into the magnetic field forming a narrow (‘pancake-like’) tongs of supersonic plasma streams (in practice, a thin plasma layer penetrates between the magnetic field lines). This result, confirmed also by numerical modeling, calls into question the generally accepted astrophysical model of matter accretion in form of ‘accretion columns’, when the matter falls onto the star from the inner edge of the accretion disc (which is formed at the magnetic/plasma dynamic pressures balance region) along the magnetic field lines to the polar regions of the star. On the contrary, the results of the present experiment make it possible to propose an alternative model for the fall of matter onto the equator of the star.