Physics of Expanding Plasmas

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Plasmas need to be created by dissipating energy in a limited volume. In this active plasma, density and temperature rise leading to elevated pressures. As a consequence the plasma expands from the plasma source to lower pressure. The expanding plasma is recombining of nature. Examples are laser spots, cathode spots, remote source plasma treatment, and the large scale plasma expansions in flares and jets in astrophysics.

In the introduction general features will be discussed, based on existence demands to the ionizing plasma in the source. Here plasma (energy) loss is balanced by production, and consequences for plasma expansion follow. Most emphasis will be given to moderate energy dissipation, and single ionized systems. But some attention will be paid to more energetic systems with ions at higher ionization stages and magnetic field generation.

The expansion of moderate scale is then described in detail and will be shown that it is not unlike classical gas expansion. The expansion, first supersonic is followed by a stationary shock. After the shock front the expansion is subsonic.
Two additional important mechanisms will be indicated: the anomalous scattering out of small mass particles in a higher mass background, the mass de-focussing, and anomalous scattering in of ambient gas into the over expanded region of the shock structure.
These features will be documented with detailed velocity distribution measurements.

A magnetic field influences the expansion in two ways: it reduces the axial decay of density by the magnetic confinement. But also it induces rotation, which can lead to ion heating by viscosity.

A short summary will be given of the consequence for the kinetics of expanding plasmas, in presence of molecules. Mechanisms which influence formation of molecular fragments, and the generation of new molecules will be described. A distinction will be made between ‘forward’ kinetics, the formation of radicals in the expanding plasma beam, and the background kinetics, mainly molecule formation by surface association. The importance of rotation/vibration excitation will be indicated. Some examples will be shown to illustrate the mechanisms.

The contribution will end with an outlook on how these features may alter strategies in plasma treatment, but also for the intended program on plasma surface interaction with expanding plasma beams.