2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Gas dependent X-rays enhancement in Mesoscopic laser plasmas

Rakesh Kumar[1], Soubhik Sarkar[3], RamGopal[2], Vandana Sharma[1], M. Krishnamurthy[2,3]
[1] Indian Institute of Technology, Kandi, Hyderabad, Telangana
[2]Tata Institute of Fundamental Research, Hyderabad, Telangana
[3]Tata Institute of Fundamental Research, Colaba, Mumbai
e-mail: rak.tsc06@gmail.com

Abstract:

Intense ultra short laser produced plasmas are a source for high brightness, short burst X-rays[7], electrons, high energy ions[6] and Mev neutral atoms[5]. Laser energy absorption and its disbursement strongly depend on the laser parameters and also on the initial size and shape of the target. The ability to change the shape, size and material composition of the matter that absorbs light is of paramount importance not only from fundamental physics point of view, but also for potentially developing laser plasma sources tailored for specific applications. The development of a delivery mechanism of microparticles into an effusive jet in vacuum for laser plasma studies has been reported[1]. Femtosecond, milli joule class, KHz lasers interaction with substrate free, isolated, mass limited targets, has been of great interest citing many important localized and inhomogenous, electron energy disbursement and electric field enhancement features. The X-rays enhancement studies done so far in this field is confined to laser parameters and target modifications. These improvisations caused local field enhancements in micrometer range. Whereas, the effusive particle(micro particle+gas) jets have unique interaction properties because of the presence of background gas. The long interaction region caused by background gas generates low energy electrons in the millimeter scales around a near solid like density microparticle in focal volume. As the positive potential formed by laser- particle interaction survives for few tens of picoseconds, providing a accelerating potential to these background electrons. These background electrons scatters from the positive potential producing enhanced bremsstrahlung radiation. The presence of low under dense plasma background around a critically dense mesoscopic plasma is a collective plasma with unique behavior. X-rays produced from such plasmas have an enhancement in x-ray yield with the change in the background gas. We present the x-ray yield enhancement and hot electron temperature behavior in such plasmas.

At 0.5 Torr, the calculation of average charge states in the cylinder [60mm(long) and 1mm radius], symmetrical around the laser focus gives the following numbers;Ar(0.75), He(0.06), N_2(0.69); and O_2(0.89) using ADK[2] formalism of tunnel ionization. The calculations also incorporate focal volume averaging. The cylindrical region containing ionized gas forms an electron bath around the positively charged particles which in turn acts as an electron feeder into hot electron region. This bremsstrahlung radiation is directly proportional to electron density around the charge particle. The enhancement in the integrated x-ray yield inferred matches to a larger extent with the corresponding electron numbers calculated using ADK formalism. The x-ray yield enhancement from He to Oxygen is 10 times and yield is similar for Nitrogen and Argon.

More the electron feeder density into the positive potential, more the integrated X-ray yield. The idea to generate mono- energetic proton beam using Silica Hollow spheres[3] as target will be discussed and elaborated using initial results. The experimental developments and the results obtained will be presented in this poster.

References:

[1]R.Gopal, R. Kumar, V. Sharma, M. Krishnamurthy, Rev.sci.instruments, 88, 023301(2017);
[2]M.V. Ammosov, Krainov, Ristic et.al , J.Opt.Soc.Am.B9,8,(1992);
[3]M. Murakami, K. Mima, Physics of plasmas, 16, 103108,(2009);
[5]R. Rajeev, M. Krishnamurthy et.al, Nature Physics **9**, 185–190 (2013);
[6]D.R.Symes, R.A.Smith, 93, 14, physical review letters(2001);
[7]M.Anand, M. Krishnamurthy, Paul Gibbon et.al, Appl. Phys.Lett, 88, 1811111(2006).