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Contrasting physics in sources of 1-20keV emission on the Z facility[1]

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Imploding wire arrays on the 20 MA Z generator have recently provided some of the brightest laboratory sources of multi-keV photons, including $\sim$ 400kJ of Al K-shell radiation ($h\nu \sim 1 - 2keV$), 80kJ of Stainless Steel K-shell ($h\nu \sim 5 - 9$keV) and a few kJ of Kr and Mo emission ($h\nu \sim 13keV$ and $\sim 17keV$, respectively). The x-ray line emission in these sources originates from highly ionized charge states that are produced by thermalization of the high kinetic energies imparted to the ions by the jxB force. Spectroscopy demonstrates that pinch pressures can approach $\sim$ 40 Mbar. Here we discuss how the physics of these x-ray sources fall into three categories. Al wire arrays produce a column of plasma with densities up to $\sim 3.10^{21}$ions/cm^3. In this regime opacity limits the radiation from increasing linearly with the emitter density. Significant structure from instabilities can reduce the density and increasing the surface area, therefore increasing the total emission. The opacity of the column can be experimentally assessed using a Mg dopant. In contrast, Stainless Steel wire arrays operate in the traditional regime where implosion velocity is critical and, while opacity is present, it has less impact on the pinch emissivity. We have recently developed a technique for determining the implosion velocity based on the radiation pulse shape, demonstrating direct correlation between implosion velocity (up to 130cm/μs), electron temperature in the stagnated pinch (up to 5keV) and the emissivity of K-shell photons (up to 80kJ). At higher photon energies, the velocities required for traditional thermal K-shell emission become prohibitive. Instead, recent experiments aim to optimize the production of hot electrons; these hot electrons cause inner-shell ionization leading to the production of non-thermal K-alpha emission. We contrast experimental data indicative of these different effects and discuss how they affect the radiative output of pinch plasmas, and how this insight can be used to better optimize these radiating pinches.

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