# Soft x-ray yield from NX2 plasma focus

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The Lee model code is used to compute neon soft x-ray yield $Y_{sxr}$ for the NX2 plasma focus as a function of pressure. Comparison with measured $Y_{sxr}$ shows reasonable agreement in the $Y_{sxr}$ versus pressure curve, the absolute maximum yield as well as the optimum pressure. This gives confidence that the code gives a good representation of the neon plasma focus in terms of gross properties including speeds and trajectories and soft x-ray yields, despite its lack of modeling localized regions of higher densities and temperatures. Computed current curves versus pressure are presented and discussed particularly in terms of the dynamic resistance of the axial phase. Computed gross properties of the plasma focus including peak discharge current $I_{peak}$, pinch current $I_{pinch}$, minimum pinch radius $r_{min}$, plasma density at the middle duration of pinch $n_{pinch}$, and plasma temperature at middle duration of pinch $T_{pinch}$ are presented and the trends in variation of these are discussed to explain the peaking of $Y_{sxr}$ at optimum pressure. © *2009 American Institute of Physics*.
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## I. INTRODUCTION

Plasma focus has been demonstrated as potential x-ray source for various medicobiological and industrial applications such as lithography[1–4] (using ~0.9–1.5 keV photons), radiography,[5,6] microscopy[7,8] (using ~0.25–2.5 keV radiations), and micromachining[9] (using ~4 keV photos). This has led to an increasing interest in exploiting the plasma focus device as a viable intense x-ray source due to some clear advantages such as being relatively cheap, compact, and ease of construction. The x-ray emissions from plasma focus devices have been explored over the wide range of capacitor bank energies ranging from large megajoule and few hundred kilojoule banks[10] to medium sized kilojoule banks[4,11–14] to subkilojoule banks of miniature sized focus devices.[15,16] In the past few years various efforts have been made for enhancing the x-ray yield by changing various experimental parameters such as bank energy,[17] discharge current, electrode configuration (shape and material),[11,13] insulator material and dimensions,[11] gas composition, and filling gas pressure.[5] Thus, soft x-ray yield optimization studies on the plasma focus devices operating over the wide range of bank energies have been one of the actively pursued fields of plasma focus research owing to their vast possible applications. Currently used systematic trial and error experimental procedure to obtain the optimized conditions for maximum radiation yield is highly time-consuming. Hence, the quicker optimization of plasma focus device is highly desirable, which can be achieved if the reliable focus model and corresponding simulation code to predict the x-ray yields from plasma focus device can be developed and used. Obviously the computed yields need to be checked against corresponding measured yields. Further, if the computed soft x-ray yields are consistently reliable against measured values; then it is reasonable to use the computed gross plasma properties as indicative of what we can expect when these plasma properties are measured. In this way, a reliable model code cannot only be used to compute radiation yields, but also be used as a good indicative diagnostic tool for multiple gross plasma properties of the plasma focus.

In the present paper, we used the Lee model code version 13.6b to carry out the numerical experiments on NX2 plasma focus device to compute its neon soft x-ray yield $Y_{sxr}$ as a function of filling gas pressure. The NX2 is a 3 kJ plasma focus originally designed to operate as a neon soft x-ray source with 20 J per shot at 16 shots/s with burst durations of several minutes.[4] Its performance in repetitive mode has been extensively studied, especially in regards to its discharge currents and soft x-ray yield $Y_{sxr}$. In this paper, we have simulated the operation of NX2 focus device in numerical experiments which are designed to compare its currents, dynamics, and some plasma pinch gross properties at various pressures so as to examine the role played by various relevant plasma properties on the way the $Y_{sxr}$ peaks at the optimum pressure.

## II. THE MODEL CODE USED FOR NUMERICAL EXPERIMENTS

The Lee model couples the electrical circuit with plasma focus dynamics, thermodynamics, and radiation, enabling realistic simulation of all gross focus properties. The basic model, described in 1984,[18] was successfully used to assist several projects.[14,19–21] Radiation-coupled dynamics was included in the five-phase code leading to numerical experiments on radiation cooling.[22] The vital role of a finite small disturbance speed discussed by Potter[23] in a *Z*-pinch situation was incorporated together with real gas thermodynamics and radiation-yield terms;[24] this version of the code assisted

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