THE CONCEPT OF PLASMA-FOCUS DRIVEN FUSION-FISSION HYBRID REACTORS

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The concept of Fusion-Fission Hybrid Reactor involves a subcritical fission reactor driven by the neutrons generated in a nuclear-fusion device [1-5]. Theoretical studies have shown that special subcritical assemblies are able to multiply considerably the neutron flux by using neutron cascades. There is still no general consensus on which would be the optimum fusion device that can be used as neutron source to feed the subcritical cascades. There are energetic, economic, and geometrical constraints which should be considered and balanced; but recent theoretical studies suggest that simplicity and volume would be the key concepts. Among the possible candidates to comply with these requirements, Plasma Focus (PF) devices [6] have emerged as a very interesting alternative, bringing about the concept of Plasma-Focus driven Fusion-Fission Hybrid Reactors (PF-FFHR).

PF are special types of fusion devices (beam-target and thermonuclear) based in the dynamic plasma-pinch effect, which achieves transient self-confinement by means of the Lorentz force. Essentially, an intense electrical discharge generates a plasma sheath in a coaxial configuration of electrodes, which ends up producing a plasma column very dense and hot [6]. When Deuterium-Tritium is used as filling gas, intense neutron pulses from fusion reactions are emitted, which can be used as the source in a subcritical cascade at very low cost and volume. The electric energy used in every discharge is an indicator of the size and neutron intensity of the device: small devices range up to 10 kJ and are easy to build and manipulate, medium-size devices are about tens of kJ and require more complex but entirely feasible technology, and there are large PF facilities of hundreds of kJ up to 1 MJ, which are more difficult to build and operate.

The feasibility of PF-FFHR has been theoretically demonstrated recently in several studies. Particularly, a joint study carried out in a collaborative project between Chile and Argentina National Nuclear Agencies showed that PF no larger than a few tens of kJ is necessary to reach hybrid break-even [7]. Since then, several other studies continued with this research line, greatly improving the mentioned figure and even proposing radiation applications and actinides burning.

The key features that determine the efficiency of the subcritical cascade are, as with most fission assemblies, the geometry and the materials. Clausse et al. (2015) [7] derived a simple analytical procedure to estimate the geometric parameters of a subcritical two-spherical-layers configuration. The accuracy of the results was assessed with Monte Carlo calculations, showing that the model is conservative in the sense that predicts 30% less neutrons that Monte

Carlo, mainly because only one-group of neutrons is used. Nevertheless, the simplicity of the analysis provides a useful tool for conceptual design.

In the present work, we present the results of several subsequent theoretical studies performed with Clausse et al.'s model. Chiefly, the impact of some of the parameters on the performance of a conceptual PF-FFHR is analyzed. Moreover, advances in the miniaturization and compactification of PF devices are also presented.

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