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Theoretical Tritium Breeding Ratio Limits and Neutron Multiplication in Fusion Breeding Blankets

This project involves using Monte Carlo neutron transport simulations (OpenMC) to analyze the effectiveness of various lithium-based materials for tritium breeding in fusion reactors. The tasks include:

- Determining the theoretical Tritium Breeding Ratio (TBR) limit for different lithium materials by simulating an infinite sphere with a 6-meter inside diameter exposed to fusion neutrons.
- Introducing a finite neutron multiplication layer and evaluating its effect on TBR by testing multiple neutron multiplication materials and layer thickness.
- Performing an enrichment study, varying the isotopic composition, and evaluating the effects of TBR.
- Generating graphs of lithium enrichment vs. TBR, both with and without neutron multiplication.

Materials to be Tested

- Liquid Lithium
- FLiBe (Li_2BeF_4)
- Lithium Lead (LiPb)
- Lithium Orthosilicate (Li_4SiO_4)
- Lithium Titanate (Li_2TiO_3)
- Lithium Zirconate (Li_2ZrO_3)
- Lithium-based ternary alloys such as LiBaBi, LiPbBa, LiSnZn, LiCuPb, LiGaPb, LiSrPb, LiPbZn, and LiNaSn.

Deliverables

- A table of theoretical maximum TBR values for each material.
- Plots of enrichment vs. TBR, with and without neutron multiplication.
- A table summarizing optimal neutron multiplication thickness/material for each lithium breeding material.
- A brief report on findings, including key trends and conclusions.

This study aims to evaluate whether neutron multiplication is beneficial for optimizing tritium production and to determine the best lithium-based materials for fusion blanket applications.