Letters to the Editor

Comments on "Conceptual Design and Neutronics Analyses of a Fusion Reactor Blanket Simulation Facility"

Beller et al.[1] refer to our previous work[2,3] with the following remark: "Additionally, recent independent studies have demonstrated that the boundary condition on a slab causes drastic differences between the hard spectrum in a cylindrical fusion reactor and the softer spectrum in a slab simulation."

There is a fundamental misunderstanding that needs to be corrected, even though some time has passed since the publication of Ref. 1.

It is true that there are drastic spectral differences between a cylindrical reactor and a slab simulation. However, Refs. 2 and 3 report that the slab spectrum is harder and the neutron spectrum in a cylindrical fusion blanket is softer. In a slab simulation, the back-reflected neutrons, having a decreased and consequently lower energy, leave the blanket definitely on the left boundary, so that the neutron spectrum in a slab is dominated only by the incident 14-MeV neutrons. In a cylindrical blanket, the back-reflected neutrons pass through the fusion reaction chamber and enter into the blanket. This back and forth reflection occurs several times, so that the neutron spectrum in the cylindrical blanket is superimposed by the incident 14-MeV fusion neutrons and reflected low-energy neutrons. Consequently, the neutron spectrum in a cylindrical blanket is softer than that in a slab simulation. Detailed analyses of this fact are presented in Refs. 2 and 3.

Beller et al.[1] mention further that, "An alternative, which has not been used in past fusion reactor blanket simulation experiments, is to create a neutron-generating system that will produce a continuous 14-MeV line source."

The first paper published that described a continuous 14-MeV line source for fusion reactor blanket simulation experiments was presented to the international scientific community at a conference in November 1984 (Ref. 4). In addition, Ref. 5 represents a very detailed analysis of a cylindrical fusion blanket experimental design where a 14-MeV line neutron source is simulated with the help of a movable point neutron source. In the course of extensive studies, different blanket compositions driven by a 14-MeV line neutron source and the related neutron physics problems have been investigated and the most relevant results were published[6-14] before Ref. 1.

At this point, it seems appropriate to add a brief comparison between the blanket type in Ref. 1 and those in Refs. 4 through 14. In Ref. 1, the line neutron source is simulated with the help of a sweeping deuteron beam. The cylindrical blanket contains a side window for the penetration of the deuteron beam. This opening disturbs the radial symmetry and the neutron spectrum becomes dependent on the azimuthal angle θ. It is practically impossible to correctly calculate this blanket with the help of one- or two-dimensional codes. The problem is of a three-dimensional nature.

On the other hand, all cylindrical blankets in Refs. 4 through 14 that contain a simulated line neutron source have an absolute radial symmetry in all θ directions. Hence, these blankets can more easily be analyzed with the help of one- or two-dimensional codes.

Aside from the above-mentioned points, I have full appreciation of the work presented in Ref. 1.

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Reply to "Comments on 'Conceptual Design and Neutronics Analyses of a Fusion Reactor Blanket Simulation Facility'"

In Ref. 1, Şahin addresses three issues regarding our paper[2] on the Fusion Reactor Blanket Facility (FRBF); one concerns an inadvertent error, one concerns a claim of lack of originality, and one concerns the conclusion of the research in Ref. 2. I address the author's points in his order.

First, in crediting the previous work of Şahin et al., I inadvertently reversed the distinction between the neutron spectrum at the first wall of a fusion reactor blanket and that at the first wall of a slab simulation. They predicted that the former would be softer.[3,4] However, the purpose of our statement in Ref. 2 was to demonstrate the need for a new fusion blanket experimental facility; the hard/soft distinction was secondary. I agree that the spectra will be greatly different.

In Şahin's second point, he implies, but does not state clearly, that I ignored his previous design work and that I claim to be the first to conceive of a line source in a cylindrical simulation. I do not claim to originate the concept of a cylindrical geometry for fusion or other experiments, as many others have considered cylindrical facilities with axial line sources [the conceptual design of the Purdue University Fast Breeder Blanket Facility (FBBF) was reported[5] in 1975]. Our statement in Ref. 2 that cylindrical fusion blanket experiments with an axial line source had not been *conducted* is still true.

Şahin's third issue, that the facility he and others conceived, AYMAN, is more appropriate for one- or two-dimensional analysis than the FRBF requires an extensive reply. Major differences between his conceptual AYMAN facility and our conceptual FRBF include the designs of the neutron generator (target geometry) and of the blanket. First, the production of 10^{11} n/s requires a high-energy, high-current deuterium beam. For a moving point source, as in AYMAN, a small target area results in a large heat load in the target. This requires an extensive cooling structure to prevent migration of tritium from the target (or else the lifetime of the target is short and the source strength is time dependent). This cooling structure asymmetrically attenuates source neutrons and destroys the axial symmetry of the neutron source. Thus, the only symmetry in the AYMAN facility is azimuthal, and at least two-dimensional computations will always be required. Additionally, if the neutron generator is not radially and azimuthally symmetric, such as the high-source-strength rotating target neutron source,[6] then AYMAN will always require three-dimensional calculations. A discussion of the impact of the neutron generating system on symmetries was not included in the referenced papers.

Additionally, Ref. 2 discusses the need to provide an axial neutron source distribution that matches the axial dependence of the flux in the blanket. When this is the case, lateral transport can be approximated by a spatial separation, while the space and energy variations are computed in the remaining one or two dimensions. Since the axial source distribution in AYMAN designs is linear, it would not match a cosine-shaped axial flux distribution in the blanket. Therefore, separation of the flux function into a spatial dependency in one dimension (axial) and a space and energy dependency in other dimensions (radial) for transport calculations would be inappropriate. However, the axial flux profile inside the blanket of the FRBF was predicted to match the chopped-cosine source distribution (demonstrated in Ref. 2 for two different fusion blankets). Thus, buckling factors can be used to approximate the axial leakage of neutrons in an R-θ simulation in the FRBF.

The FRBF does have an asymmetry, however, because of a slot required to introduce a modulated deuteron beam. This beam sweeps along an axial tritiated target; thus, the time-averaged power density of the beam on the target is orders of magnitude less than AYMAN. This allows minimal cooling materials, improves the azimuthal symmetry of the source, and increases the lifetime of the target. The axial slot for the deuterium beam, however, disturbs the azimuthal symmetry within the blanket.

Past research for the design of the FBBF (Ref. 7) and Refs. 2 and 8 demonstrated that at large azimuthal angles (~60 deg) away from a geometric discontinuity, the flux asymptotically approaches that found in *azimuthally symmetric* systems. Thus, at ~60 deg from the beam slot, one-dimensional neutronics studies could be performed to evaluate the detailed energy dependence as a basis for producing accurate coarse-group constants. These fewer group constants could then be used in two-dimensional studies (R-θ), and detailed analyses of experimental results from the FRBF *would not* require three-dimensional calculations. Thus, the uncertainties that are normally associated with fairly coarse three-dimensional treatments would be avoided.

In *summary*, the FRBF does not duplicate past fusion blanket simulation experiments, and it would provide a combination of source and geometry that would permit two-dimensional predictions of experimental results. I inadvertently reversed the distinction between the neutron spectrum in a cylindrical fusion reactor and in a slab-geometry simulation experiment, as predicted by Şahin et al.

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