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Ensuring accurate fieldline-body intersection

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Abstract The problem of calculating the intersection between straight-line rays and solid bodies has been intensively studied as it has widespread application in radiation transport, acoustics, optics and high frequency electromagnetics more generally. Less attention has been paid to the case when the rays are curved, as found in seismics and which in application to plasma physics might be caused by spatial variation of the dielectric tensor. Typically the ray trajectory is simply treated as a series of short, straight-line segments

A plasma application where this simple approach might not always be adequate is the related problem of calculating the intersection made between magnetic fieldlines and the first wall of a magnetically confined fusion system such as the tokamak. In the strong applied magnetic field, particle motion and energy transport is constrained at thermal energies to follow fieldlines, to a good approximation in the absence of collective or fluid effects. Such an approximation is believed to apply in the scrape-off layer lying between the well-confined core plasma and the first wall of the tokamak. Since the density of surface energy deposition becomes greater as device size increases (on simple dimension scaling arguments), much effort has been devoted to producing a first wall design for the larger ITER tokamak that ensures the energy lost in the scrape-off layer is spread as widely as possible over the wall surface, by arranging for near tangential alignment with the field. Due to other engineering constraints such as the need for modularity of the blanket, the resulting first wall design has a geometrically complex surface, ultimately defined as part of a Computer Aided Design (CAD) database.

There is also the problem of ensuring that the magnetic fieldlines are followed accurately, regardless of whether they intersect any objects. The combined problem, that of ensuring curved rays intersect accurately with CAD geometry, has been solved using a specially chosen and implemented Runge-Kutta-Fehlberg (also known as Embedded RK) scheme. Results demonstrating the efficacy of the technique, and describing its application to realistic first wall designs, will be presented.

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