

# Reply to the comment by A.A. Skovoroda

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Skovoroda notes that stellarator and mirror physics contain concepts which are largely unfamiliar to the tokamak physicist. Most of them refer to qualities of the magnetic field, e.g.,

- omnigenous: the radial guiding-centre drift vanishes on an orbit average for all particles,
- quasi-isodynamic: omnigenous and poloidal precession of trapped particles,
- quasi-symmetric:  $|B|$  is independent of a linear combination of the toroidal and poloidal Boozer angles.

These terms appear in Section 2 of our paper as an introduction to the main kinetic calculation in the following section. Skovoroda criticises us for not mentioning two further classes of fields:

- pseudo-symmetric: all level contours of  $|B|$  are poloidally, helically or toroidally closed,
- isometric:  $B$  depends on the arc length  $l$  along the field in the same way for all field lines on each flux surface  $\psi$ , i.e.,  $|B| = f(\psi, l)$ . This implies that the distance along  $\mathbf{B}$  between different contours of  $|B|$  is independent of the field line.

However, these concepts do not play any independent role in our calculation. Pseudo-symmetry is a necessary, but not sufficient, condition for omnigenicity [1], which, contrary to the assertion of Skovoroda, does not imply isometry [2]<sup>1</sup>. The results in our paper about the neoclassical properties of quasi-isodynamic fields do not in general

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<sup>1</sup>Cary and Shasharina [3] appear to use the word “isometry” differently, meaning that the distance between points with the same  $|B|$  on either side of a minimum should be independent of the field line. Omnigenicity then *does* imply isometry.

hold for pseudo-symmetric ones. In the following list, each class of magnetic fields is a subset of the following one:

quasi-symmetric  $\subset$  isometric<sup>2</sup>  $\subset$  quasi-isodynamic  $\subset$  omnigenous  $\subset$  pseudo-symmetric.

In practice, what one wants to achieve is good confinement (omnigenity or quasi-isodynamicity) and perhaps undamped rotation (=quasi-symmetry [6]), but not isometry or pseudo-symmetry *per se*.

## References

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<sup>2</sup>As Skovoroda has shown himself, however, in stellarators the distinction between isometry and quasi-symmetry is academic, since they coincide whenever the rotational transform is irrational [4, 5]