Researchers propose novel permanent magnet design methods for quasi-axisymmetric stellarator

October 8 2021, by Zhang Nannan

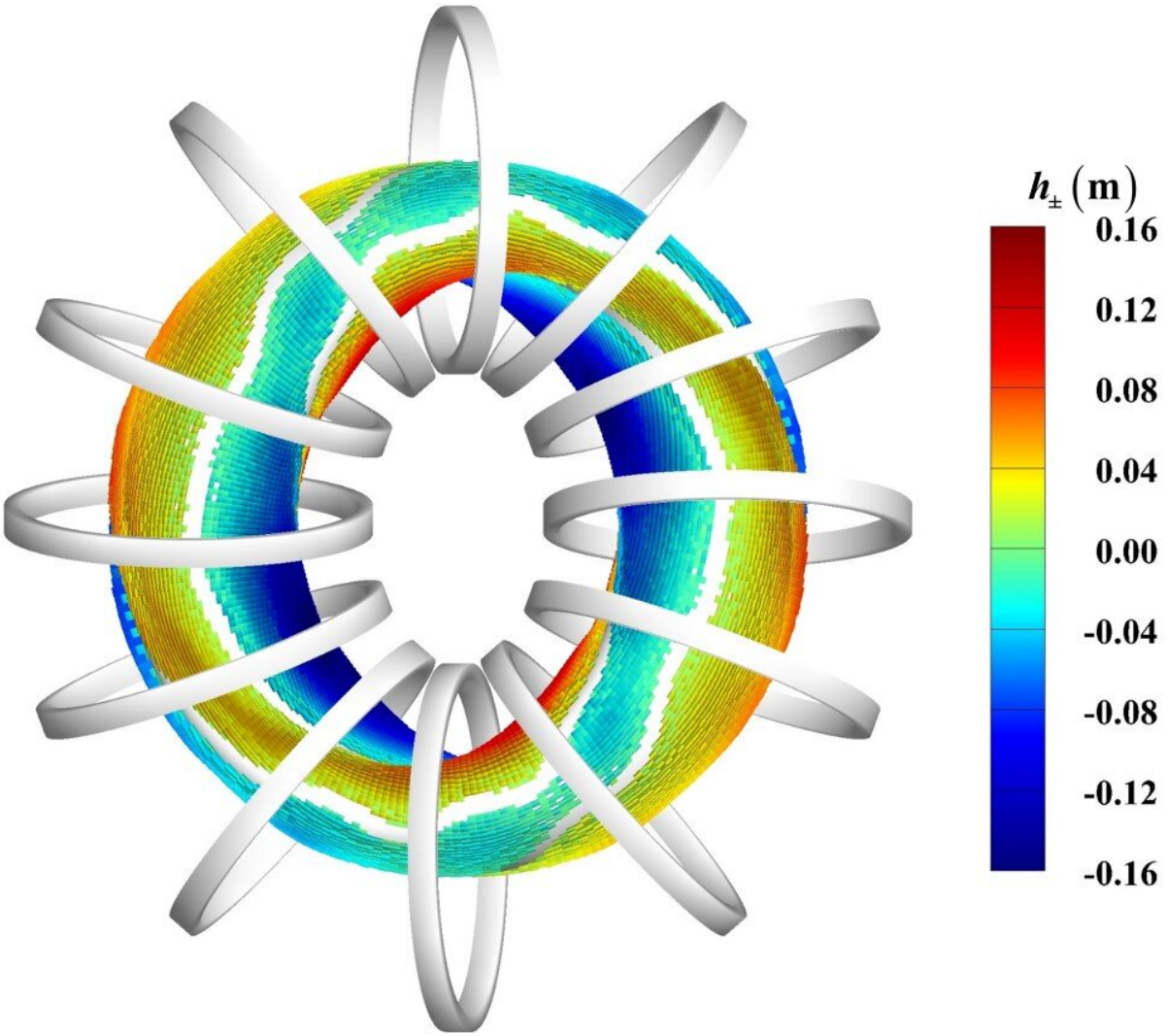

Fig. 1. Perpendicular magnets designed using the "two-step" magnet design

strategy. Credit: LU Zhiyuan

A new permanent magnet design of quasi-axisymmetric stellarator was made by researchers led by Prof. Xu Guosheng from the Hefei Institutes of Physical Science (HFIPS) of the Chinese Academy of Sciences.

The "two-step" magnet design strategy further verifies the practicability of this method and lays a solid foundation for the subsequent design of standardized magnet. Related achievements have been published in *Nuclear Fusion*.

In recent years, the advanced stellarator approach for fusion energy research has obtained remarkable progress. The permanent magnet has the advantages of no energy consumption, low cost and natural steady state, thus it has the potential to greatly reduce the construction and operation cost of the stellarator. However, since a large number of magnet blocks (104~106) are needed for a permanent magnet stellarator, the fabrication and assembly of these magnet blocks and precision control may be even more difficult and costly than 3D coils. Therefore, how to simplify even standardize the magnet design now is a key issue for permanent magnet stellarator.

In this research, the researchers proposed Fourier decomposition method to design perpendicular magnets, which can generate the required magnetic field with high accuracy and the least magnet consumption.

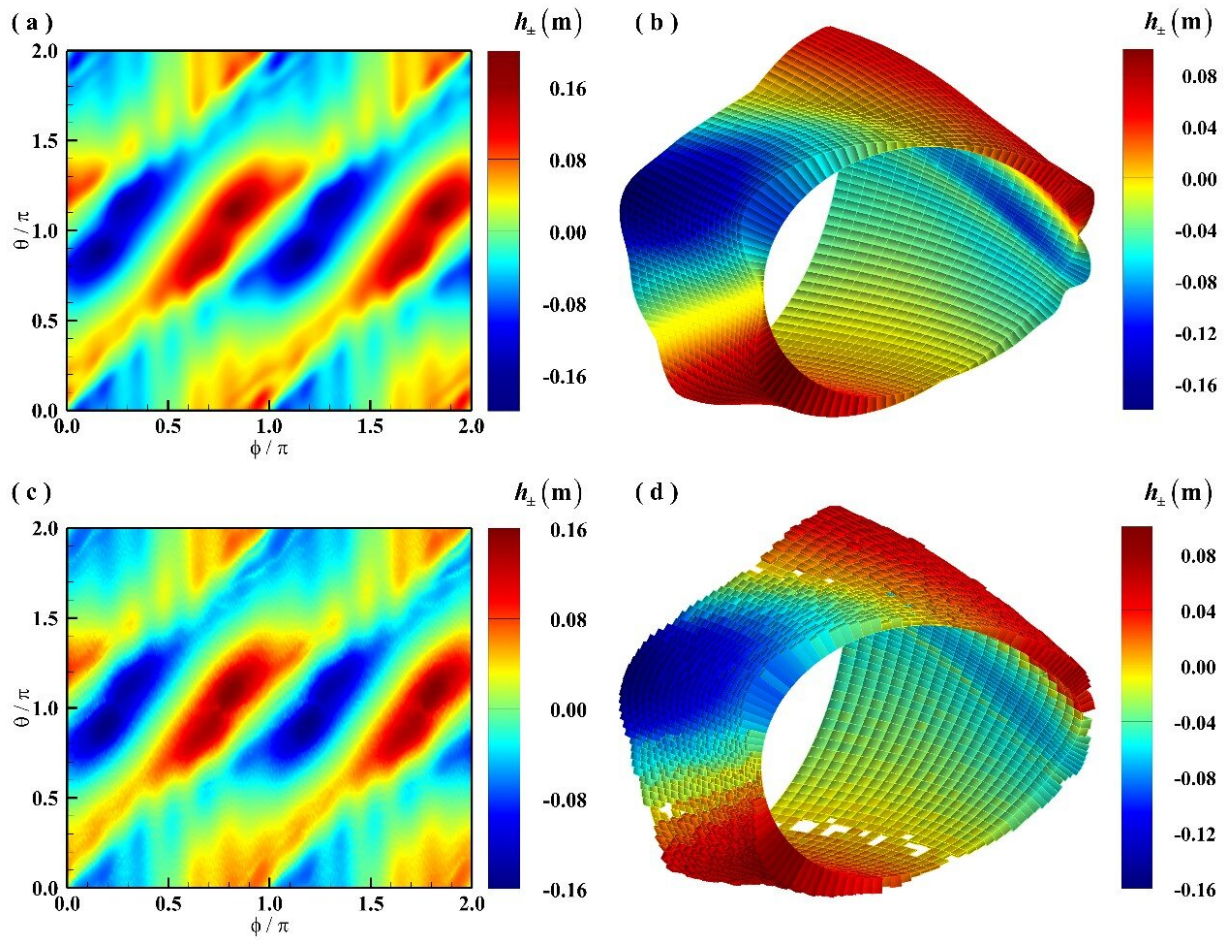

Fig. 2. The "two-step" magnet design strategy can give almost the same design as the Fourier decomposition method. Credit: LU Zhiyuan

All the perpendicular permanent magnets have the same remanence and only one single layer of magnets are mounted on the vacuum vessel, which can be easily inserted into the cells of a gridded frame attached to the vacuum vessel and fixed with springs from the back.

"This design greatly simplified the manufacture, assembly and maintenance of the magnets, and thus facilitates precision control and cost reduction," said Prof. Xu Guosheng.

The "two-step" magnet design strategy was proposed based on the "divide and conquer strategy," which is robust, efficient and simple in logic. With this strategy, the design process of a large number of magnet blocks is decomposed into independent designs of each magnet block, and then iterates to find the solution, thus the specific form of each magnet block can be regularly customized and the magnets suitable for the engineering implementation can be easily designed.

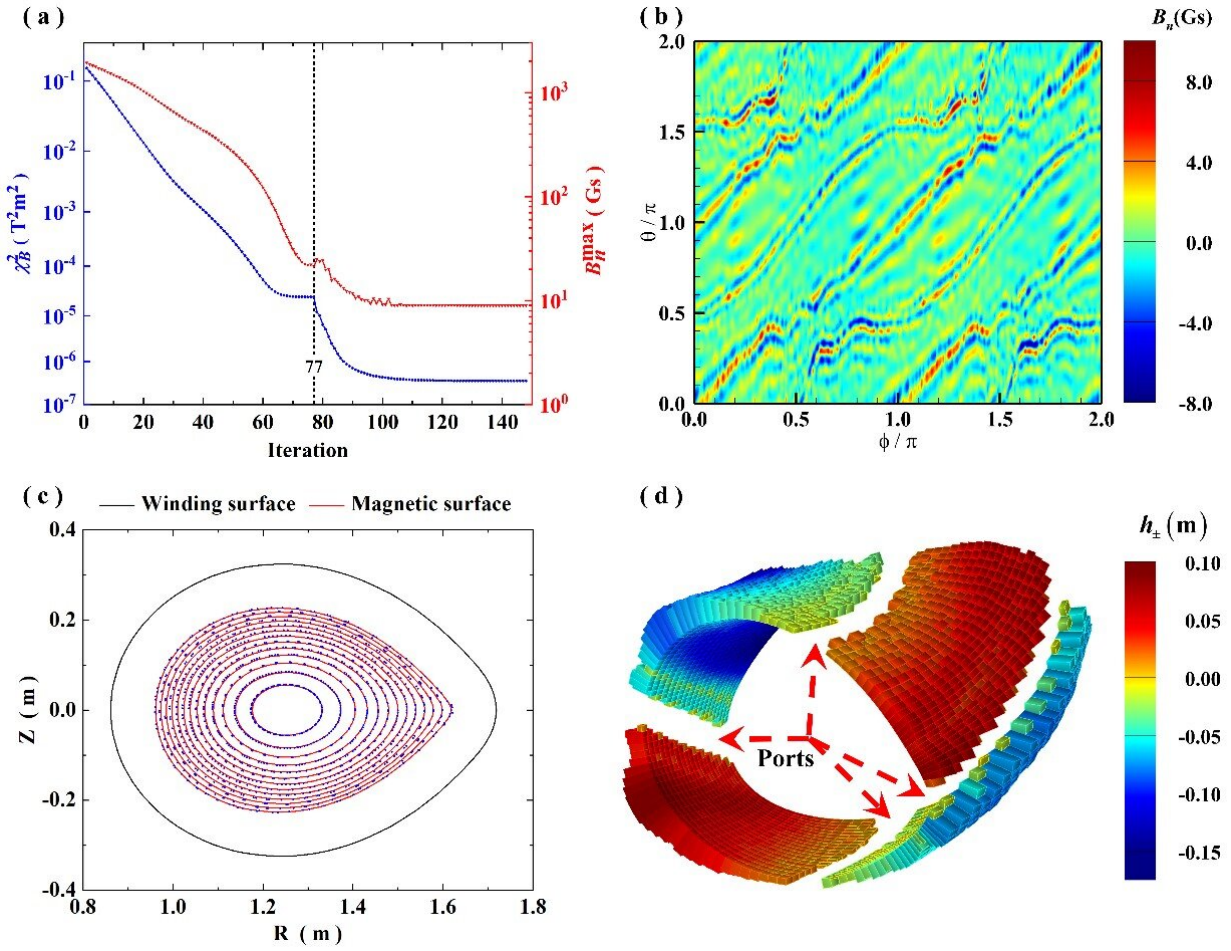

Fig. 3. The "two-step" magnet design strategy can automatically design ports for plasma heating and diagnostics. Credit: LU Zhiyuan

This strategy gives almost the same magnet design as the Fourier decomposition method, which validates the practicability of this strategy and lay a solid foundation for the subsequent design of standardized magnet.

More information: G.S. Xu et al, Design of quasi-axisymmetric stellarators with varying-thickness permanent magnets based on Fourier and surface magnetic charges method, *Nuclear Fusion* (2020). DOI: 10.1088/1741-4326/abcdb6

Z.Y. Lu et al, Design of quasi-axisymmetric stellarators with variable-thickness perpendicular permanent magnets based on a two-step magnet design strategy, *Nuclear Fusion* (2021). DOI: 10.1088/1741-4326/ac1710

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