Stellarator - Hidden Symmetry and Prospect

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A stellarator is a magnetic confinement concept in which most of the helical magnetic field is generated externally, unlike tokamaks, which rely on internal inductive currents. This feature makes the stellarator intrinsically free from disruptive instabilities and inherently capable of steady-state operation; however, its magnetic asymmetry can degrade confinement. This challenge is resolved through a hidden symmetry in charged-particle trajectories, known as quasi-symmetry or, more broadly, omnigeneity, as demonstrated by modern stellarators such as W7-X in Germany. Maintaining this hidden symmetry in three-dimensional configurations requires highly complex optimization, but recent advances in optimization algorithms, including AI-based methods, have enabled compelling stellarator designs suitable for both experimental devices and fusion reactors. One example is a flexible stellarator capable of realizing two distinct quasi-symmetric configurations within a single device, as demonstrated in recent integrated design studies at Seoul National University. This talk will present Korea's first stellarator R&D program in the context of recent worldwide advances in stellarator research.