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Implementation of the thermodynamic and phase transition equations of superfluid helium in a CFD software

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The cryogenic design of the next generation of superconducting accelerator magnets depends on our ability to simulate the helium heat and mass transfer in the internal structure of these magnets. For that matter accurate tools must be developed such as numerical codes integrating the thermodynamic behavior and phase transition in superfluid helium. Moreover it would also help to understand the fundamental behavior of superfluid helium in confined geometries as the ones created by the structure of the magnet, i.e. electrical insulation, space between the collars···

We have implemented in 2D and 3D the He II conservation equations in Fluent© CFD software corresponding to a simplified two-fluid model. It consists of a conventional continuity equation, a modified momentum equation for the total fluid and an energy equation including the Gorter-Mellink internal convection term modeling the turbulence regime. The code is mainly suited to simulate transient and steady-state flow configurations. At the walls, heat transfers are conjugated with Kapitza resistance. In addition, a new method has been developed to simulate the He II / He I transition in 2D based on a modified Volume Of Fluid method (VOF). The interface between the two states of liquid helium has been locally recreated in the corresponding cells to properly mimic the second order phase transition (no latent heat).

Both steady and unsteady numerical simulation have been performed and compared with different experimental results.

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