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The Future with Cryogenic Fluid Dynamics

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The applications of cryogenic systems have expanded over the past 50 years into many areas of our lives. During this time, the impact of the common features of Cryogenic Fluid Dynamics, CFD, on the economic design of these cryogenic systems, has grown out of a long series of experimental studies carried out by teams of postgraduate students at Southampton University.
These studies have sought to understand the heat transfer and convective behaviour of cryogenic liquids and vapours, but they have only skimmed over the many findings made, on the strong convective motions of fluids at low temperatures. The convection takes place in temperature gradients up to 10,000 degrees K/meter, and density gradients of 1000% per meter and more, with rapid temperature and spacially dependent changes in physical properties like viscosity, surface tension, etc, making computer modelling almost impossible without experimental data. These temperature and density gradients are far larger than those met in other convecting systems at ambient temperatures, and there is little similarity.
The paper will discuss the likely impact of CFD on future cryogenic systems, and hopefully inspire further research to support and expand the use of existing findings, and to improve the economy of present-day systems even more effectively.
Particular examples to be mentioned include the following.
Doubling the cooling power of cryo-coolers by a simple use of CFD.
Reducing the boil-off rate of liquid helium stored at the South Pole, such that liquid helium availability is now all-the-year-round.
Helping to develop the 15 kA current leads for the LHC superconducting magnets at CERN, with much reduced refrigeration loads.
Improving the heat transfer capability of boiling heat transfer surfaces by 10 to 100 fold.

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