Numerical simulations and experiments of electromagnetically driven turbulent flows

Project leaders
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Research theme
Complex dynamics of fluids
Mathematical and computational methods for fluid flow analysis

Participants
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Cooperations
TU Dresden; Institute of Physics, Riga; FZR Rossendorf, Dresden; University of Grenoble; University of Maryland, College Park

Funded
KNAW, TU Delft
1st 25% 2nd - 3rd 75%

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Project Aim

Th Numerical simulations and modeling of thermal and magnetic convection at very high Rayleigh and Hartmann numbers has long been a serious challenge because of the profound effects that buoyancy and Lorentz forces have on the reorganization of the vortical structures, and because of the extreme thinning of the wall boundary layers which requires high numerical resolution. The aim of this study is to develop physically well-based and numericalla efficient approaches to tackle problems of highly turbulent thermal and magnetic convection in complex geometries.

Progress

Targeting accurate predictions of heat transfer at very high Ra numbers, the performance of T-RANS with a low-Re 3-equation sub-scale model and hybrid seamless RANS/LES have been compared to well-resolved LES in the 107<Ra<109 range. Whilst the application of conventional coarse grid LES resulted in 50% under-prediction of Nusselt at Ra=109, the T-RANS results showed excellent agreement for heat transfer with both well-resolved LES (107<Ra<109) and experiments (106<Ra<1016). In order to sensitize the T-RANS approach to high-frequency instabilities, different ways of hybrid seamless RANS/LES merging have been investigated. It is demonstrated that the new hybrid approach is capable of capturing a significantly larger portion of the fine-structure spectrum than possible with T-RANS, whilst also returning accurate predictions of heat transfer and turbulence statistics. In addition to T-RANS approach, a magnetically extended SGS model in LES framework has been applied in an intermediate range of Ra numbers.

Dissertations

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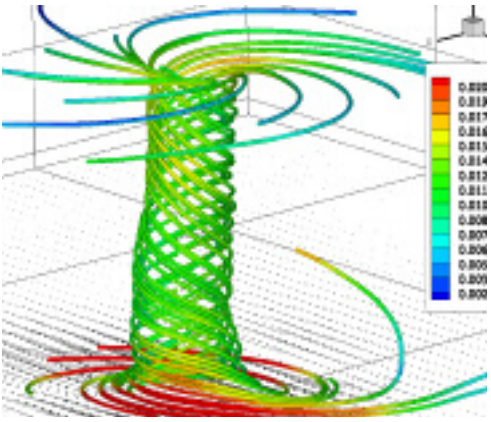
Scientific Publications

1. Kenjeres, S. (2008), "Electromagnetic Enhancements of Turbulent Heat Transfer", Physical Review E, Vol.78,066309, 5 pp, DOI: 10.1103/PhysRevE.78.066309.
2. Kenjeres, S., Verdoold, J., Tummers, M. J., Hanjalic, K. and Kleijn, C. R. (2008), "Numerical and experimental study of electromagnetically driven vortical flows", Proceedings of the 7th International ERCOFTAC Symposium on Turbulence Modelling and Measurements, ETMM-7, 4-6 June 2008, Limassol, Cyprus, Vol.2, pp.364-369.



Electromagnetically generated swirling flow of an electrically conductive fluid in turbulent flow regime (Re=10000), a combination of two permanent magnets (|B|=1 T) and two electrodes (I=10 A) - mutually perpendicular to each other.