Heat transport in rotating convection captured by invariant solutions

J.-C. Ringenbach[*], S. M. Tobias[†] and T. M. Schneider[*]

Rotation affects transport properties such as heat transport in thermally-driven convection. This is the case in astrophysical bodies' atmospheres as well, where the body's rotation and magnetic fields both influence transport properties. The interaction of convection with rotation and magnetic fields is also believed to be a key component of the dynamo effect[1].

We consider a 2D horizontally periodic domain, representing an atmosphere slice at a given latitude, with rotation oblique to the vertical gravity[2]. It is made 2D by averaging over the longitudinal direction of the 3D case. The fluid considered behaves as a Boussinesq fluid, heated at the bottom wall and cooled at the top one.

We conduct direct numerical simulations (DNS) at various Rayleigh numbers Ra, keeping fluid (thermal and momentum diffusivities) as well as system (domain size, latitude and rotation rate) properties fixed to reproduce DNS data[3], where a non-trivial jump in heat transport around $\mathrm{Ra} \approx 6.3 \times 10^5$ is observed.

In order to understand the abrupt change in heat transport, represented by the Nusselt number Nu, we construct invariant solutions such as equilibria, and follow their bifurcations. Since invariant solutions are building blocks of the dynamics, we use them to track parameter dependence of Nu.

A summary of the different results from DNS as well as a bifurcation diagram of the first non-trivial stable fixed point are shown in Figure 1.

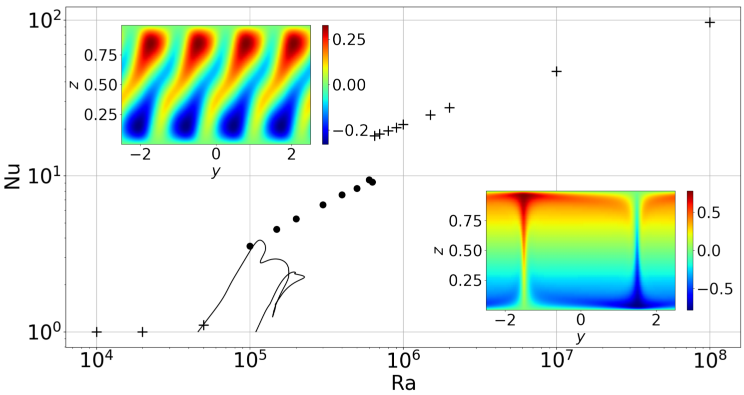

Figure 1: Temperature fluctuations at $\mathrm{Ra} = 9.1 \times 10^4$ (left) and $\mathrm{Ra} = 6.5 \times 10^5$ (right). Data points are taken from DNS: *circles* represent time averages over chaotic dynamics and *pluses* stable fixed points. The line is a continuation from the first non-trivial fixed point.

[*]Dep. Physics, EPFL, Lausanne, 1015, CH
[†]Dep. Applied Mathematics, Leeds University, Leeds, LS2 9JT, UK

[1]Tobias, *J. Fluid Mech.* **912**, P1 (2021)
[2]Hathaway and Somerville, *J. Fluid Mech.* **126**, 75-89 (1983)
[3]Currie, *The Driving of Mean Flows by Convection* (2014)