Nematic - isotropic phase transition in turbulent thermal convection

GUENTER AHLERS, STEPHAN WEISS, Department of Physics, University of California, Santa Barbara, USA — The nematic-isotropic transition of a liquid crystal (LC) at a temperature $T_{NI}$ is an example of a soft phase transition, where fluid properties, although discontinuous, change only very little and where the latent heat is small. Understanding thermal convection in the presence of such a phase change is relevant to convection in Earth’s mantle where discontinuous changes of the crystalline structure occur. We report on turbulent Rayleigh-Bénard convection of a nematic LC while it undergoes a transition from the nematic to the isotropic phase in a cylindrical convection cell with aspect ratio $\Gamma$ (height over diameter) of 0.50. The difference between the top- and the bottom-plate temperature $\Delta T = T_b - T_t$ was held constant, while the average temperature $T_m = (T_b + T_t)/2$ was varied. There was a significant increase of heat transport when $T_{NI}$ was between $T_b$ and $T_t$. Measurements of the temperatures along the side wall as a function of $T_m$ showed several ranges with qualitatively different behavior of quantities such as the time-averaged side-wall temperature, temperature gradient, or temperature fluctuations. We interpret these different ranges in terms of processes in the thermal boundary layers close to the top and bottom plates.

1SW acknowledges support by the Deutsche Forschungsgemeinschaft. This work was supported by the U.S. National Science Foundation through Grant No. DMR11-58514.

Stephan Weiss
Department of Physics, University of California, Santa Barbara, USA

Date submitted: 24 Jul 2013