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Universality and extreme tail fluctuation properties in transport systems

John Bruun (1) and Spiros Evangelou (2)

(1) Independent Academic Researcher, Independent Senior Scientist (CPhys, MInstP, FRSS), United Kingdom (john.bruun@hotmail.com), (2) Physics Department, University of Ioannina, Greece.

In nature universal properties can be exhibited in dynamical and chaotic systems. In climate systems it has recently been shown that El Niño Southern Oscillation (ENSO) modes exhibit chaotic resonance structure that is consistent with a period attractor structure and intermittency (Bruun et al., 2017). That work also asked the question: Is the current instability of the ENSO modes and example of the hysteresis characteristic changing in the industrial period? The extreme value process of the climate system may be sensitive to system changes such that the extreme tail distribution properties may alter (Bruun and Tawn, 1998, Gouldby et al., 2017). Extreme value process transitions have been studied in other physical systems where the random matrix theory universality concepts and the statistical mechanics of disordered mesoscale quantum transport are used to assess universality and chaotic system properties (Evangelou and Pichard, 2000; Bruun et al, 1995, Bruun, 1994). The extreme value distribution is a form of geometric universal probability distribution that results from a max stable limit law. This means that the tail of an extreme value process follows a well parametrised distribution, and with suitable inference it provides an opportunity to describe extreme value characteristics (Tawn, 1988; de Haan, 1984). In this work we take the opportunity to show extreme value process transitions in an exactly specified mesoscale quantum transport system for quantum coherent systems. The coupling dynamics are specified by the Bogoliubov-de Gennes (BdG) equation. The BdG represents the coupled interactions and scattering properties that combine to create a range of remarkable phenomena such as Anderson localisation, superconductivity and universal conductance fluctuations. We also discuss how the analysis concepts developed in mesoscale quantum transport, and extreme value process distributions can be utilised in climate science to help assess the chaotic system structure, intermittency and to establish a statistical mechanics formulation of the ENSO climatic hysteresis function.

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