Nonlinear transport in nonequilibrium systems (with an application to Tokamak-plasmas)

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CHAOS
Volumen: 30
Número: 6
DOI: 10.1063/5.0006213
Fecha de publicación: JUN 2020
Tipo de documento: Article
Ver impacto de la revista

Abstract

We show, for the first time, the explicit form of the nonlinear partial differential equations (PDEs) subject to the correct boundary conditions that have to be satisfied by transport coefficients having a vanishing skew-symmetric piece. We also report, for the first time, the nonlinear PDEs (with the appropriate boundary conditions) for transport coefficients when the thermodynamic system is subject to two thermodynamic forces. Since the proposed PDEs have been derived without neglecting any term present in the dynamical equations (i.e., the energy, mass, and momentum balance equations), we propose them as a good candidate for describing transport in thermodynamic systems also far from equilibrium (e.g., in the turbulent regime). The preliminary test was carried out by analyzing a concrete example where Onsager's relationships manifestly disagree with experience: magnetically confined Tokamak-plasmas. More specifically, we focus our calculations to compute mass and energy transports in Frascati Tokamak Upgrade-plasmas subject to two thermodynamic forces. We show a good agreement between the theoretical predictions and the experimental data. The aim of this study is to apply our approach to the Divertor Tokamak Test Facility, to be built in Italy, and to the International Thermonuclear Experimental Reactor.

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Editorial

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Información de la revista

- **Impact Factor:** Journal Citation Reports

Categorías / Clasificación

Áreas de investigación: Mathematics; Physics

Categorías de Web of Science: Mathematics, Applied; Physics, Mathematical

Información del documento

Idioma: English

Número de acceso: WOS:000539397200010

ISSN: 1054-1500

eISSN: 1089-7682