Mathematical Physics

Applications of Classical Scaling Symmetry

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Any symmetry reduces a second-order differential equation to a first-order equation: variational symmetries of the action (exemplified by central field dynamics) lead to conservation laws, but symmetries of only the equations of motion (exemplified by scale-invariant hydrostatics), yield first-order {\em non-conservation laws} between invariants. We obtain these conservation laws by extending Noether's Theorem to non-variational symmetries, and present a variational formulation of spherical adiabatic hydrostatics. For scale-invariant hydrostatics, we directly recover all the published properties of polytropes and define a {\em core radius}, a new measure of mass concentration in polytropes of index n. The Emden solutions (regular solutions of the Lane-Emden equation) are finally obtained, along with useful approximations. An appendix discusses the special n=3 polytrope, emphasizing how the same mechanical structure allows different {\em thermostatic} structures in relativistic degenerate white dwarfs and and zero age main sequence stars.

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