Accepted Manuscript

Non-equilibrium dog-flea model

Bruce J. Ackerson

PII: S0378-4371(17)30480-6
DOI: http://dx.doi.org/10.1016/j.physa.2017.04.170
Reference: PHYSA 18272

To appear in: *Physica A*

Received date : 1 February 2017

Please cite this article as: B.J. Ackerson, Non-equilibrium dog-flea model, *Physica A* (2017), http://dx.doi.org/10.1016/j.physa.2017.04.170

Non-equilibrium Dog-Flea Model

Bruce J. Ackerson[1]

[1]*Department of Physics, Oklahoma State University, Stillwater, Oklahoma 74078, USA*

We develop the open dog-flea model to serve as a check of proposed non-equilibrium theories of statistical mechanics. The model is developed in detail. Then it is applied to four recent models for non-equilibrium statistical mechanics. Comparison of the dog-flea solution with these different models allows checking claims and giving a concrete example of the theoretical models.

I. INTRODUCTION

Equilibrium statistical mechanics began with Clausius (1850a,b), Boltzmann (1896) and Gibbs (1902) and is well developed today. Maximizing entropy subject to constraints proves a powerful method to predict average properties of a thermodynamic system without detailed knowledge of microscopic dynamics. Non-equilibrium statistical mechanics has made progress but remains an active area of development today. Variational principles are sought to provide similar reductions in microscopic dynamical knowledge needed to predict average properties. These include MaxEnt, MEP, and MaxCal (Presse 2013).

Onsager (1931; De Groot and Mazur 1962) considered small departures from equilibrium to develop a theory of flows and thermodynamic forces where the production of entropy is linearly related to the flows. Positive entropy production and microscopic reversibility lead to the now famous reciprocal relations. Prigogine (1971; Glansdorff) argued that unconstrained thermodynamic forces should spontaneously reduce to zero, giving a minimum entropy production principle.

Jaynes (Jaynes 1957a; Jaynes 1957b) reformulated equilibrium statistical mechanics in terms of information theory and Shannon's definition of entropy. Rather than assuming an objective frequentist understanding of probabilities, Jaynes is interested in making the best prediction based on limited data. He is not concerned with ergodic theory. If maximizing the entropy, subject to certain constraints, doesn't give acceptable results, the proper formulation requires additional or different constraints. Maximizing the entropy (MaxEnt) should work for both equilibrium and non-equilibrium problems. In non-equilibrium, the probability of fluxes rather than states are used to express the entropy (Niven 2009).