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Equilibration, generalized equipartition, and diffusion in dynamical Lorentz gases

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We demonstrate approach to thermal equilibrium in the fully Hamiltonian evolution of a dynamical Lorentz gas, by which we mean an ensemble of particles moving through a d-dimensional array of fixed soft scatterers that each possess an internal degree of freedom to which moving particles locally couple. We show that the momentum distribution of the moving particles approaches a Maxwell-Boltzmann distribution at a certain temperature T, provided that they are initially fast and the scatterers are in a sufficiently energetic but otherwise arbitrary stationary state of their free dynamics—they need not be in a state of thermal equilibrium. In our treatment, the temperature T to which the particles equilibrate is defined through a fluctuation-dissipation-like relation that emerges naturally from the microscopic Hamiltonian dynamics as a result of dynamical friction ; it obeys a generalized equipartition relation, in which the associated thermal energy $k_{\mathrm{B}}T$ is equal to an appropriately defined average of the scatterers' kinetic energy. In the equilibrated state, particle motion is diffusive.

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