



2026-2027 EOAS Colloquium Series

Where Is the Second Law of Thermodynamics Hiding? — An Answer to a 150-Year Puzzle

The Second Law of Thermodynamics tells us that heat always flows from hot to cold, that a shattered glass never reassembles itself, and that ink dropped into water spreads but never gathers back. This one-way nature of physical processes is what physicists call the "arrow of time." But here lies a paradox that has troubled physicists for 150 years: the Newtonian mechanics governing molecular motion is perfectly time-symmetric. **So how can a macroscopic world built from reversible microscopic motions be irreversible?** This is Loschmidt's Paradox. The bridge between the microscopic and macroscopic worlds is the Boltzmann equation, whose construction requires a mathematical condition known as the Boltzmann-Grad (BG) limit. For more than 75 years, everyone interpreted this condition as a neutral technical assumption, unrelated to the Second Law. This paper proves that interpretation is wrong. This condition actually defines the surface area of each small cell of gas. Because molecular motion is isotropic in three dimensions, a hotter cell has a larger surface area, and more molecules cross from the hotter cell into the cooler cell than in the opposite direction, carrying greater momentum and energy. The Second Law — heat flows from hot to cold — is not an additional postulate. It is the inevitable consequence of Newton's First Law: molecules in the absence of external forces continue their inertial motion. The Second Law was hiding inside the Boltzmann-Grad limit all along. Loschmidt's Paradox dissolves: the wrong question has been asked for 150 years. The framework connecting the microscopic to the macroscopic was never time-neutral to begin with. Newton's First Law, Newton's Second Law, and the Second Law of Thermodynamics are mutually compatible — and Newton's First Law is the bridge between them.



Dr. Zhaohua Wu

**Department of Earth, Ocean, and Atmospheric Science
Florida State University**

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Location: EOA 1044

Contact: Zhaohua Wu (zwu@fsu.edu)