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Stability of Nonrelativistic Matter

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The stability of matter is often assumed without question. We typically believe that established physical theories can easily predict that atoms and molecules will not collapse or that the total energy of matter scales linearly with the number of particles. However, these questions remained unresolved when quantum theory was first established, and it actually took several decades before any proof was provided. In this talk, we present Lieb's proof of the stability of non-relativistic matter. By modeling matter as a system of N particles interacting under Coulomb forces, we show how to derive a linear bound for the total energy of the system as a function of N; that is, to find a constant k such that $\mathcal{E}(\psi) > kN$ for every wave function ψ of the system. To achieve this, we apply the Lieb-Thirring inequalities in the context of Schrödinger operators and use a semiclassical approximation of the Coulomb energy. Finally, we discuss how this linear bound for the total energy leads to the conclusion that matter is extensive and bosonic matter is unstable.

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