Thermal non-equilibrium in solar coronal loops: from coronal rain to long-period intensity pulsations

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The complex interaction of the magnetic field with matter is the key to some of the most puzzling observed phenomena at multiple scales across the universe, from tokamak plasma confinement experiments in the laboratory to the filamentary structure of the interstellar medium. King among these is the phenomenon of coronal heating. The solar corona is the outer layer of the Sun's atmosphere and, like most stars in the universe, it is permeated by closed magnetic structures called coronal loops filled with plasma at multi-million-degree temperatures, hundreds of times hotter than the underlying photosphere, the Sun's surface. Detecting heating mechanisms in action has proved very difficult, particularly because of the lack of resolution in hot lines of current instrumentation and also because the coronal magnetic field is largely unknown.

However, the corona also conceals a cooling problem. Indeed, recent observations indicate that, even more mysteriously, like snowflakes in the oven, the corona hosts large amounts of cool material termed coronal rain, hundreds of times colder and denser, that constitute the seed of the famous prominences. Numerical simulations have shown that this cold material does not stem from the inefficiency of coronal heating mechanisms, but because of the specific spatiotemporal properties of these. As such, a large fraction of coronal loops is suspected to be in a state of thermal non-equilibrium, characterised by heating and cooling cycles whose telltale observational signatures are long-period intensity pulsations in hot lines and periodic coronal rain in cool lines, now ubiquitously observed. In this talk, I will present this yet largely unexplored strong connection between the observed properties of cool material and the coronal heating mechanisms, which constitutes a new, rapidly growing field of solar physics.