The Thermo-Alfvénic instability --- from toy model to torus

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A comprehensive understanding of electromagnetic effects on the microinstability properties of tokamak plasmas is becoming increasingly important as experimental values of the plasma beta and, therefore, electromagnetic fluctuations will be higher in reactor-relevant tokamak scenarios. Despite significant numerical progress in understanding the behaviour of instabilities such as the micro-tearing mode (MTM) or kinetic ballooning mode (KBM), there is still a lack of clarity about the fundamental physical processes that are responsible for them, owing to the complexity of full toroidal geometry. Constructing simplified models offers a path towards distilling the fundamental physical ingredients behind electromagnetic destabilisation. This talk focuses on electromagnetic instabilities driven by the electron-temperature gradient (ETG) in a local 'toy' model of a tokamak-like plasma. The model has constant equilibrium gradients (including magnetic drifts, but no magnetic shear) and is derived in a low-beta asymptotic limit of gyrokinetics. A new instability is shown to exist in the electromagnetic regime, the so-called 'thermo-Alfvénic instability' (TAI), whose physical mechanism hinges on a competition between diamagnetic drifts (due to the ETG) and rapid parallel streaming along perturbed field lines. Using linear gyrokinetic simulations, the TAI's presence is confirmed in slab geometry, validated against solutions to an analytical dispersion relation. The mapping of the TAI onto a more realistic magnetic equilibrium is considered, demonstrating that it survives aspects of the transition to toroidicity. A comparison is then drawn with the properties of the MTM and KBM, contextualising the TAI within the wider 'zoo' of electromagnetic instabilities commonly observed in tokamak simulations.