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Linear stability of the flow in a toroidal pipe PHILIPP SCHLATTER, JACOPO CANTON, RAMIS OERLUE, KTH Mechanics — While hydrodynamic stability and transition to turbulence in straight pipes has been studied extensively, the mechanisms leading to instability in curved pipes are less documented. Here, the first (linear) instability of the flow inside a toroidal pipe is investigated as an initial step in the study of the related laminar-turbulent transition process. In the toroidally bent pipe, the flow is governed by two parameters: the Reynolds number and the curvature of the torus, given as the ratio between the radii of the pipe and of the torus, and is maintained in motion by fixed axial flux. We use classical modal stability analysis, which includes computing nonlinear steady states for each parameter pair, and then studying the stability by solving an eigenproblem of the linearised Navier–Stokes operator. Results show that the flow is indeed modally unstable for all the studied curvatures in the range 0.01–1, with the Reynolds number about 3000. The frequency, wavenumber and mode shapes are strongly dependent on the curvature: The corresponding critical modes are mainly located in the region of the Dean vortices, and represent in general travelling waves. Also time-dependent nonlinear simulations highlight the importance of the linear modes in the transition process in the bent pipe.

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