Destabilizing external damping in theory and experiment

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In elastic structures loaded by nonconservative forces, such as the follower forces, the role of damping is twofold. It can both stabilize and destabilize stable equilibria of undamped structures [1]. Since 1952 the destabilizing role of the internal Kelvin-Voigt viscous damping is well-known for the two-linked Ziegler's pendulum, continuous Beck's column, and Pflüger's column [2, 3, 4]. The result is the so-called 'Ziegler destabilization paradox', where the critical force for flutter instability decreases by an order of magnitude when the coefficient of internal damping becomes infinitesimally small. Until now external damping, such as that related to air drag, is believed to provide only a stabilizing effect, as one would intuitively expect [5, 6]. However, some early studies [7, 8] questioned this common belief by presenting nonconservative elastic systems destabilized by external damping caused by the dash-pots attached to the structure. Nevertheless, these counterexamples remained in the shadow of the stabilizing effect of air drag on the stability of the classical Ziegler pendulum and Beck's column. We show that actually the effect of external damping is qualitatively the same as the effect of internal damping, yielding a pronounced destabilization paradox in the Ziegler's and Pflüger's elastic structures for almost all mass distributions. Previous results relative to destabilization by external damping of the Ziegler's and Pflüger's systems are corrected in a definitive way leading to a new understanding of the destabilizing role played by viscous terms. The theoretical predictions of the work [3] are verified in a dedicated experiment with the Pflüger column [9].

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