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The combined effect of electron and proton firehose instabilities for the solar wind plasma conditions

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In the absence of collision, kinetic instabilities triggered by velocity space anisotropies of plasma particles play an essential role in limiting the deviations from isotropy. For example, in the solar wind, firehose instabilities may inhibit the growth of the temperatures in the direction parallel to the background magnetic field, counterbalancing the effect of the expansion. Electron and proton firehose instabilities can be triggered depending on the plasma parameters and the different branches within (periodic and aperiodic). Despite the significant difference between electron and proton spatial and temporal scales, both modes can work together to alter the dynamic of the plasma.
We use a fully kinetic 2D semi-implicit particle-in-cell simulation, iPic3D, to study the evolution and interplay of firehose instabilities triggered by electrons and protons when both species are anisotropic. The aperiodic electron firehose instability remains largely unaffected by the proton anisotropy and saturates rapidly at low-level fluctuations. On the other hand, the presence of anisotropic electrons has a considerable impact on the proton firehose modes, especially on the aperiodic branch, shifting the onset of the instability and boosting the saturation levels of the fluctuations. Anisotropic electrons contribute to more effective regulation of the proton anisotropy.