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ABSTRACT

Title

The influence of anomalous Doppler waves on the Hyperloop stability

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Abstract

The Hyperloop is an innovative transportation system that is currently under development. It minimizes air resistance by enclosing the vehicle in a de-pressurized tube and eliminates wheel-rail contact friction through the use of an electromagnetic suspension/levitation, similar to Maglev trains. This design can potentially achieve much higher velocities compared to traditional railways, positioning the Hyperloop as an environmentally friendly alternative to air transportation.

A potential challenge for Hyperloop is ensuring the dynamic stability at large velocities, where multiple instability sources can be present. An apparent source is the electro-magnetic suspension (adopted by some designs) making a control strategy mandatory to ensure stability even at quasi-static velocities. A less obvious instability mechanism is that the vibration of a vehicle on an elastic guideway can become unstable when surpassing a critical velocity.

The authors have previously investigated the interplay between the electro-magnetic and wave-induced instability mechanisms and showed that the stability space changes significantly above a certain velocity. In other words, the control strategy can ensure the overall system stability only for a very limited range of its gains. The cause for this drastic change was attributed to the wave-induced instability mechanism. Metrikin demonstrated that this instability arises with the radiation of anomalous Doppler waves, which introduce more energy to the vehicle's vibration than normal Doppler waves radiate away from the vehicle. The current study demonstrates that the change of stability domain is indeed caused by the anomalous Doppler waves. While identifying unstable velocity regimes is practical for Hyperloop design, gaining insight into the contribution of individual instability mechanisms can be crucial for efficient mitigation.

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