An analytical model of how the negative triangularity cuts off the access to the second stable region in tokamak plasmas

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We present an analytical model to evaluate the triangularity-shaping effects in accessing the second stable region for the ideal ballooning mode [1]. Our results indicate that if the triangularity is sufficiently negative, the path from the first to the second stable region will be closed. The reason is that negative triangularity can weaken the stabilizing effect of the 'magnetic well', and even convert the 'magnetic well' into a 'magnetic hill', which will destabilize the ballooning mode. We also show that the synergistic effects of elongation, inverse aspect ratio, and safety factor can reopen the path to the second stable region. Through a variational approach [2], we derive an analytical expression of the critical negative triangularity for closing the access to the second stable region. Furthermore, our analysis reveals that in the second ballooning stable regime, the negative triangularity tends to inhibit the emergence of quasi marginally stable discrete Alfvén eigenmodes [3]. These findings provide a quantitative understanding of how the negative triangularity configuration impacts the confinement of tokamak plasmas.

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