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The N/D study on the singularity structure of πN scattering amplitudes

The N/D method is used to study the S_{11} channel low energy πN scattering amplitude. The inputs of left cuts are obtained from various phenomenological models at tree level. With the aid of the production representation, the total phase shifts can be decomposed into different contributions, and it further reveals that the existence of subthreshold resonance $N^*(890)$ doesn't depend on the details of the dynamical inputs. Additionally, it is found that there exist virtual states in partial waves, which are induced by the u channel nucleon exchanges. These virtual states accumulate at the end point of the u channel
segment cut. The end point is hence the essential singularity of the full amplitude on the second sheet of complex s plane.

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