

Scattering from two-piece rising potentials: a new avenue of resonances

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We study scattering from potentials that rise monotonically on one side; this is generally avoided. We report that resonant states are absent in such potentials when they are smooth and single-piece (like in the cases of Morse oscillator, exponential and linear potentials). But when these potentials are made two-piece, resonances can occur. We further show that rising potentials next to a well/step/barrier are rich models of multiple resonances (Gamow's decaying states) in one- dimension. We use linear, parabolic and exponential profiles as rising part and find complex-energy poles, $\mathcal{E}_n = E_n - i\Gamma_n/2$ ($\Gamma_n > 0$), in the reflection amplitude (s-matrix). The appearance of peaks in Wigner's (reflection) time-delay at $E = \epsilon_n$ (close to E_n) and spatial catastrophe in the eigenfunction confirm the existence of resonances and meta-stable states in these systems.