ID de Contribution: **3** Type: **Non spécifié**

Analytic structure and power-series expansion of the Jost matrix

vendredi 14 octobre 2011 15:00 (40 minutes)

The N-channel Schroedinger equation has exactly N linearly independent regular solutions. Each of them is a column-matrix of the length N. Written next to each other, they form a square (N,N)-matrix, which is called the fundamental matrix of regular solutions. Any physical solution is a linear combination of its columns. Asymptotically, the fundamental matrix behaves as the superposition of the incoming and outgoing multi-channel spherical waves (which are diagonal square matrices composed of the Riccati-Hankel functions). In such a superposition, the energy dependent amplitudes of the waves are the Jost matrices that determine the S-matrix. For a short-range interaction, at each threshold energy (where a channel momentum is zero) the Jost matrices have a branching point. Separating the odd powers of all channel momenta and then expanding the remaining single-valued functions of the energy E in powers of (E-E0) near an arbitrary point E0 in the complex plane, we obtain a semi-analytic expression for the Jost-matrix where the square-root E-dependencies at all the branching points are given explicitly and the energy-independent expansion coefficients can be obtained as asymptotic values of the solutions of a set of simple differential equations. This approach generalizes the standard effective-range expansion and in the suggested form can be used not only near the thresholds, but near an arbitrary point E0 on the Riemann surface of the energy within the domain of analyticity. The semi-analytic expression for the Jost-matrix (and therefore for the S-matrix) can be used to locate the spectral points (bound and resonant states) as the S-matrix poles. Alternatively, it can be used for extracting the resonance parameters from experimental data. In doing this, the expansion coefficients (instead of being calculated) can be treated as fitting parameters to reproduce experimental data on the real axis (near a chosen energy) and then the resulting semi-analytic Jost-matrices can be used at the nearby complex energies for locating the resonances. Similarly to this approach, which is valid in three-dimensional space, we obtained the expansions for the Jost functions describing the systems in a space of an even dimension, where the logarithmic branching points are present.

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