Scattering in a Chebyshev Particle

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Electromagnetism allow us to study the depths of the Universe, as well as the inner workings of our human cells. Most of it is done essentially by means of scattering phenomena, e.g., x– rays scattering, Rayleigh, and many more. To achieve a theory which explains the dynamics of the electromagnetic wave in a medium and its interfaces, it is common to use three scattering functions, namely, the transmission and reflection amplitudes, and the refractive index.

In quantum mechanics, we can also define an analogous refractive index for matter–waves, henceforth referred to as *quantum refractive index* [1,2], and study a material or medium with the help of this newly defined scattering function, with hopes of acquiring information unobtainable via electromagnetic waves. In this work, we study the scattering of a plane-wave by a two-dimensional wavy circle, i.e., a Chebyshev particle [3,4]. To accomplish this, we use a boundary-wall potential [5] with coupling strength γ to represent our wavy circle. The wavefunctions, scattering amplitudes and cross-sections, and the quantum refractive index are determined by solving the Lippmann–Schwinger equation in the position-representation.

The *exact* solution for the Lippmann–Schwinger equation is achieved with the help of the eigenfunction expansion in circular polar coordinate systems, by which orthogonality properties allow us to represent the wave functions and the other relevant scattering functions in series expansions. More specifically, we successfully obtain an exact expression for the quantum refractive index, and we note that it is a complex function of the incident wavenumber k as well as of the coupling strength γ. For certain special values of the scattering parameters (k and γ), and particle parameters (ε and β, the deformation and undulation parameters respectively), its real part can be negative, and its imaginary part can be positive, negative, and even zero, which evokes an analogy with electromagnetic materials with negative refractive indexes [6].

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