

ON THE RELATIVISTIC TWO-CENTRE PROBLEM

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Considerable interest has arisen in the relativistic two-centre problem due to extensive theoretical and experimental studies to investigate the various phenomena associated with the supercritical heavy-ion collisions ($Z_1+Z_2 \geq 173$)^{1,2}. During such a collision the nuclei form a superheavy nuclear system and the electronic states are exposed to the two-centre potential of the colliding nuclei for a very short duration. The empty 1S-bound state is expected to dive into the negative energy continuum with the spontaneous emission of the positrons. This study is of great significance as detection of these positrons will verify the prediction of decay of neutral vacuum into the charged vacuum. The study of the two-centre Dirac equation (TCD) is essential to tackle this problem.

Up to now the TCD has been treated in the 'mono-pole approximation'³. Chandel and Mukherjee⁴ had suggested another approach to solve the TCD for the scattering case. Using the Furry-Sommerfeld-Maue approximation, the TCD is converted into a Schrödinger-type equation and the solutions of the TCD are constructed from the known solutions of the Schrödinger-type equation⁵. The differential scattering cross section is obtained in terms of two-centre phase shifts $\sigma_{m\ell}$. These phase shifts can be calculated by a higher-order semiclassical method⁶. One of the interesting features of $\sigma_{m\ell}$ is that they tend to spherical Coulomb phase shifts σ_{ℓ}^C for large ' ℓ ', e.g. for a 100 MeV electron this value of ℓ is 7, for an interseparation of two charges $R=1.18 \times 10^{-13}$ cm⁷. This simplifies the complicated two-centre problem considerably as one has to calculate $\sigma_{m\ell}$ for small ' ℓ ' and for higher ' ℓ ' spherical Coulomb phase shifts can be substituted. The computation of the differential scattering cross section also simplifies considerably as the two-centre scattering amplitude F_{TC} can now be expressed as

$$F_{TC} = (F_{TC} - f_C) + f_C,$$

where f_C is the spherical Coulomb scattering amplitude. In $(F_{TC} - f_C)$ a small number of partial waves will be needed as higher ones will coincide with spherical Coulomb waves. The application of the formalism to positron emission is under investigation.

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