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INTERACTION OF A NEUTRAL COMPOSITE PARTICLE WITH A STRONG COULOMB FIELD*

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INTERACTION OF A NEUTRAL COMPOSITE PARTICLE WITH A STRONG COULOMB FIELD*

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As is well known, a neutral particle such as a neutron interacts with an external magnetic field because of the composite nature of the particle. The interaction of a neutral composite system with an external electric field in the form of a polarization potential is also well known. An interesting question arises whether there can be additional higher-order interaction terms which are small for weak fields but become very important in a strong Coulomb field. This question is of interest in its own right but has acquired additional impetus in view of the observation of sharp positron lines in quasi-elastic heavy-ion reactions with large combined charge numbers ($Z > 164$) near the Coulomb barrier.¹ The growing body of experimental data suggests the production of a quasi-stable composite (e^+e^-) system in the presence of a strong Coulomb field. Their experimental production implies that these objects interact strongly with the strong Coulomb field or else they will not be produced in heavy-ion collisions. We wish to use Dirac's constraint dynamics² to study how such a strong coupling between a neutral composite (e^+e^-) object and the strong nuclear Coulomb field may arise.

As there are short-range, non-central attractive forces between e^+ and e^- at a distance of a few fermi,³ we shall assume that the (e^+e^-) composite particle maintains its quasi-stability through this non-central attractive electromagnetic interaction and has a radius of a few fermi. We study the single-particle states of the composite particle around a nucleus with charge number Z . The eigenvalue equation contains terms of the kind $(p_1 - e_1 V_1)^2 + (p_2 - e_2 V_2)^2$ where p_i , e_i , and V_i are the momentum, charge, and the nuclear Coulomb potential for the i th constituent. Thus, interaction terms linear in V_i depend on the sign of the constituent charge e_i ; they tend to cancel each other and result in a small net force (polarization force). Interaction terms of the type $(e_i V_i)^2$, which is quadratic in V_i , do not depend on the sign of the constituent charge; both constituents can contribute an attractive interaction acting on the composite particle by the nuclear charge. These interaction terms are proportional approximately to $Z^2 \alpha^2 / R^2$ where α is the fine structure constant. They increase in strength rapidly as the nuclear charge Z increases and as the

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distance R between the nucleus and the composite object decreases. The eigenvalue equation contains additional spinor $\vec{\alpha}_i \cdot \nabla V_i$ terms which give a repulsive effective interaction at short distances. When the charge number Z is very large, the combined interaction can be attractive at short distances. For a point nuclear charge, the total effective interaction at short distances is repulsive for $Z\alpha < \sqrt{2}$ and is attractive for $Z\alpha > \sqrt{2}$. The attractive interaction becomes supercritical for $Z\alpha = 3/4$. When $Z\alpha$ exceeds this value, the spontaneous production of the composite particle will occur. This may be the origin of the production of the composite particle in heavy-ion reactions with a large combined charge. After the colliding nuclei recede from each other, the produced composite particle may outlive the strong field and may later decay into the detected pair of an electron and a positron.

1. T. Cowan, et al., Phys. Rev. Lett. 56, 444 (1986); P. Kienle, Ann. Rev. Nucl. Part. Sci. 36, 605 (1986).
2. H. W. Crater and P. Van Alstine, Ann. Phys. (N.Y.) 148, 57 (1983);
H. W. Crater and P. Van Alstine, Phys. Rev. Lett. 53, 1577 (1984);
H. W. Crater, C. Y. Wong, R. L. Becker, and P. Van Alstine (to be published).
3. C. Y. Wong and R. L. Becker, Phys. Lett. 182, 251 (1986).