K05b Classification of Orbits in the Kepler Problem in an Expanding Universe

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From our numerical study (Ardi, Tsuchiya, and Inagaki, 1998) of the scattering problem in an expanding universe, we found that not all orbits are scattered like orbits observed in usual Rutherford scattering, but some are trapped by the gravity of the target. This means that classification of orbits into ellipse, parabola, and hyperbola is not trivial in an expanding universe.

Therefore we try to classify the orbits in the Kepler Problem in an expanding universe as a basic problem.

We reformulate the equation of motion in the physical coordinates, rather than in the comoving coordinates. In the physical coordinates, we can characterize the effect of the cosmic expansion by a decaying harmonic potential. The energy of a particle is not conserved due to the change of the cosmic potential. Thus a particle which is initially unbounded from the Kepler potential could be bounded after the decay of the cosmic potential.

Therefore, we conduct some calculations and simulations in physical coordinate. We use three kinds of initial parameters : two-body separation R_o, initial velocity V_o and impact parameter b_o. We will report the condition of the initial parameters which lead the orbit to elliptical one at the final.