

## 1 Yukawa

In a solid, a free electron doesn't see a bare nuclear charge since the nucleus is surrounded by a cloud of other electrons. The nucleus will look like the Coulomb potential close-up, but be screened from far away. A common model for such problems is described by the Yukawa or screened potential:

$$U(r) = -\frac{k}{r}e^{-\frac{r}{\alpha}} \quad (1)$$

- (a) Graph the potential, with and without the exponential term. Describe how the Yukawa potential approximates the "real" situation. In particular, describe the role of the parameter  $\alpha$ .
- (b) Draw the effective potential for the two choices  $\alpha = 10$  and  $\alpha = 0.1$  with  $k = 1$  and  $\ell = 1$ . For which value(s) of  $\alpha$  is there the possibility of stable circular orbits?