Homework 4, due 9-27

In class we solved the Schrödinger equation for the s-wave bound state of the deuteron under the assumption that the bound state is shallow. Repeat the calculation without using this approximation. Use the potential

$$V(r) = \begin{cases} 
-V_0 & r < a \\
0 & r > a 
\end{cases}$$

with $a = 1.4$ fm. Fix $V_0$ from the measured binding energy $B = -2.2$ MeV. Determine the rms radius $\sqrt{\langle r^2 \rangle}$ of the deuteron.

Hints: You will have to solve the eigenvalue equation numerically. You can do that graphically, using your pocket calculator, or using a numerical math package such as mathematica/maple/matlab. Note that the rms radius is defined as $\sqrt{\langle r^2 \rangle}$, where $\langle r^2 \rangle$ is the expectation value of $r^2$ in the ground state. Remember that

$$\int d^3r \, f(r) = 4\pi \int r^2 dr \, f(r).$$