Units

MKS is no more appropriate when studying physics at the microscopic level (atom, nucleus, nucleons, quarks, etc ...). The MLT dimensions are replaced by a new "scale" based on energy and distance, whose basic units are the electron-volt (eV) and the Fermi (F or fm)).

\[ 1 \text{eV} = 1.6 \times 10^{-19} \text{J} \]  \hspace{1cm} (1)

Using the values of \( h \), Planck’s constant and \( c \), the speed of light\(^\text{1} \)

\[ h = 6.62606957 \times 10^{-34} \text{J} \cdot \text{s}, \quad c = 2.99792458 \times 10^8 \text{m/s} \]  \hspace{1cm} (2)

we have in this new system:

\[ hc = 1.9864457 \times 10^{-25} \text{J} \cdot \text{m} \]

\[ = 1.2415 \times 10^{-5} \text{eV} \cdot \text{m} \]

\[ = 1241.5 \text{eV} \cdot \text{nm} \]

\[ = 1241.5 \text{MeV} \cdot \text{F} \]  \hspace{1cm} (3)

For simplicity we shall consider that

\[ hc = 1240 \text{eV} \cdot \text{nm} = 1240 \text{MeV} \cdot \text{F} \]  \hspace{1cm} (4)

and

\[ \hbar c = 197.0 \text{eV} \cdot \text{nm} = 197.0 \text{MeV} \cdot \text{F} \]  \hspace{1cm} (5)

The fine structure constant (\( \alpha \)), Bohr radius and the electron Compton wavelength are respectively given by equations 6, 7 and 8.

Fine structure constant

\[ \alpha = \frac{k e^2}{\hbar c} = \frac{9 \times 10^9 \left(1.6 \times 10^{-19}\right)^2}{3.16153 \times 10^{-26}} \approx \frac{1}{137} \]  \hspace{1cm} (6)

Bohr radius

\[ a_0 = \frac{\hbar c}{\alpha \mu c^2} = \frac{197.0 \times 137.3}{0.510} = 0.53 \text{Å} \]  \hspace{1cm} (7)

Electron Compton wavelength

\[ \lambda_0 = \frac{\hbar}{m_e c} = \frac{hc}{m_e c^2} = \frac{1240}{0.511} = 243 \text{F} \]  \hspace{1cm} (8)

Where \( \mu c^2 \) is the Hydrogen atom reduced mass.

\(^{1}\) http://physics.nist.gov/constants [Friday, 03-Feb-2012]. National Institute of Standards and Technology, Gaithersburg, MD 20899.
Table 1 gives the values of the rest mass of the electron, proton, neutron and alpha particle in $MeV/c^2$ units.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Mass</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_e$</td>
<td>0.511 $MeV/c^2$</td>
<td>9-a</td>
</tr>
<tr>
<td>$m_p$</td>
<td>938.3 $MeV/c^2$</td>
<td>9-b</td>
</tr>
<tr>
<td>$m_n$</td>
<td>939.573 $MeV/c^2$</td>
<td>9-c</td>
</tr>
<tr>
<td>$m_\alpha$</td>
<td>3727.4 $MeV/c^2 = 3.7274 GeV/c^2$</td>
<td>9-d</td>
</tr>
</tbody>
</table>

Table 1: Rest mass for some particles