For the particles to interconvert they must be antiparticles of each other and so be neutral. They also must have zero baryon and lepton number. We can obviously neglect particles which are their own antiparticles. Hence we must consider neutral mesons with quark content $\bar{s}d$ and $\bar{c}u, \bar{s}b$ and $\bar{b}d$ and $\bar{b}d$ and the yet as unfound mesons $\bar{t}u$ and $\bar{t}c$ and $\bar{t}c$.

The neutron does not mix with the anti-neutron as it has non-zero baryon number.

The $K^0\ast$ is not stable and will decay by the strong force into $K\pi$ before it decays to $\bar{K}^0$. Also as $K^0$ has non-zero spin to form a CP eigenstate we would not get a $J_3$ eigenstate.

$$\Gamma = \sigma v |\Psi(0)|^2$$

with $|\Psi(0)|^2 = 1/\pi a^3$ ans $a = 2a_{Bohr}$. Sutituting in the values for $m_e, c$ and $\hbar$ we get

$$\tau = 1.39 \times 10^{-7} s$$

We are interested only in ratios so we calculate

$$\frac{\Gamma(\Psi \rightarrow \text{hadrons})}{\Gamma(\Psi \rightarrow e^+e^-)} = \frac{\sigma_{\text{hadrons}}}{\sigma_{e^+e^-}} = \frac{5\times3(\pi^2-9)\alpha_s}{184\pi} \alpha$$

$$= 1070\alpha_s^3.$$

If we use $\alpha_s = 0.2$ (see footnote on page 165) we get 8.56. The pdg tables give (once we subtract out the decay into virtual photons) 11.92. We can see that

$$\frac{\Gamma(\Psi \rightarrow \mu^+\mu^-)}{\Gamma(\Psi \rightarrow e^+e^-)} = \frac{\sigma_{\text{hadrons}}}{\sigma_{e^+e^-}}$$

$$= 1$$

as the lepton mass does not enter into the equation. Again the pdg tables give 0.99.
Using the formula

\[ M(\text{meson}) = m_1 + m_2 + A \frac{(\vec{S}_1 \cdot \vec{S}_2)}{m_1 m_2} \]

with \( A = (2m_u/\hbar)^2 160\text{MeV} \) we get

<table>
<thead>
<tr>
<th>Particle</th>
<th>Formula(Mev)</th>
<th>Observed(Mev)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D_s )</td>
<td>1919</td>
<td>1970</td>
</tr>
<tr>
<td>( D )</td>
<td>1711</td>
<td>1864</td>
</tr>
<tr>
<td>( \eta_c )</td>
<td>2980</td>
<td>2980</td>
</tr>
<tr>
<td>( \Psi )</td>
<td>3007</td>
<td>3097</td>
</tr>
<tr>
<td>( D^* )</td>
<td>1843</td>
<td>2007</td>
</tr>
<tr>
<td>( D^*_s )</td>
<td>2004</td>
<td>2112</td>
</tr>
<tr>
<td>( B )</td>
<td>4978</td>
<td>5279</td>
</tr>
<tr>
<td>( B_c )</td>
<td>6193</td>
<td>6400</td>
</tr>
<tr>
<td>( B^0 )</td>
<td>5162</td>
<td>5370</td>
</tr>
<tr>
<td>( \Upsilon )</td>
<td>9400</td>
<td>9460</td>
</tr>
</tbody>
</table>

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We have the formula (5.133)

\[ \psi(\text{baryon octet}) = \sqrt{2/3}[\psi_12(\text{spin})\psi_12(\text{flavour}) + \psi_23(\text{spin})\psi_23(\text{flavour}) + \psi_12(\text{spin})\psi_13(\text{flavour})] \]

so

\[ |\Sigma; 1/21/2\rangle = \frac{\sqrt{2}}{3}[1/2(\uparrow\downarrow - \downarrow\uparrow)(us - su)u + 1/2(\uparrow\uparrow - \downarrow\downarrow)u(us - su) + 1/2(\uparrow\uparrow - \downarrow\downarrow)u(us - su)] \]

\[ = \frac{1}{3} \sqrt{2}[u(\uparrow)s(\downarrow) - u(\downarrow)s(\uparrow) + permutations] \]

Similarly for

\[ |\Lambda : 1/2, -1/2\rangle = \sqrt{2/3} \frac{1}{2}(\uparrow\downarrow - \downarrow\uparrow)(us - su)d + (ds - sd)u \]

\[ + \frac{1}{2}(-\downarrow\uparrow + \uparrow\downarrow)(dus - dsu + uds - usd) \]

\[ + \frac{1}{2}(-\downarrow\uparrow + \uparrow\downarrow)(uds - sdu + dus - sud) \]

\[ = \frac{\sqrt{2}}{6}[u(\uparrow)s(\downarrow)d(\downarrow) - 2u(\downarrow)s(d(\downarrow) - u(\downarrow)s(d(\uparrow) + permutations], \]

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Luminosity

\[ \mathcal{L} = N_\nu n_t L \]
with $N_p$ number of particles per pulse, $\nu$ pulse frequency, $n_t$ number density of targets and $L$ the fiducial length. For liquid Hydrogen $\rho = 0.0708 \text{ g cm}^{-3}$ so $n_t = (0.0708)(6 \times 10^{23}) \text{ cm}^{-3}$ and so

$$L = 4.2 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$$

and the integrated luminosity is $L t = 6.7 \times 10^{32} \text{ cm}^{-1}$. 