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ABSTRACT

It is speculated that a nonstatic metastable σ-τ phase could explain the recently observed ion-ion cross-sections exceeding the geometrical bound.

Recent experiments[1,2] have confirmed previous observations[3] of light anomalous nuclei. These nuclei are characterized by a lifetime of at least 10^{-11} sec and by a cross-section which exceeds the geometrical bound by one order of magnitude[1].

A cross-section exceeding the geometrical bound is something so extraordinary that it seems to us to be worth while to consider any mechanism which could possibly explain it, even if an explicit calculation is not possible at present. We therefore make here some qualitative considerations relating such cross sections to a possible metastable σ-τ phase[4] (spin-up protons and spin-down neutrons displaced with respect to spin-down protons and spin-up neutrons).

Let us suppose that under the compression caused by the collision a nucleus be led to a σ-τ phase. If the separation energy between the nucleons with $\sigma_3\tau_3=1$ and the nucleons with $\sigma_3\tau_3=-1$ has a local minimum at a separation distance d_o, and if such separation distance is reached during the collision, after the collision the nucleus will remain for some time in the σ-τ phase. In such a state the phases $\sigma_3\tau_3=\pm1$ will oscillate around d_o generating a coherent pion field accordind to the equation

$$(\Box + m_\pi^2)\,\phi_3 = \frac{f}{m_\pi}\,\partial_k\, S_{k3} = \frac{f}{m_\pi}\,\partial_k \langle \bar{\Psi}\sigma_k\tau_3\Psi\rangle . \tag{1}$$

If the oscillation takes place along the 3-axis with frequency ω

$$\langle S_{k3}\rangle = \langle S_{33}\rangle\Big|_{t=0}\,\delta_{k3}\, e^{i\omega t}$$

$$\phi_3 = \phi_3(\vec{r}, t=0)\, e^{i\omega t} \tag{2}$$

and $\phi_3(\vec{r}, 0)$ will satisfly the time independent equation

$$\left[\Delta - (m_\pi^2 - \omega^2)\right]\phi_3(\vec{r}, 0) = \frac{f}{m_\pi}\,\partial_3 \langle S_{33}\rangle\Big|_{t=0} , \tag{3}$$

showing that the pion has an effective Compton wave lenght $1/\sqrt{m_\pi^2-\omega^2}$. Our suggestion is that this increased Compton wave length (combined with the dislocation d_o might explain the observed cross-section.

Note that it is essential to have a nonstatic σ-τ phase[5]. A static one[6] can give rise to coherent effects, but cannot explain a cross-section which exceeds the geometrical bound.

To establish theoretically the existence of such metastable phase is a formidable problem due to the essential role played by the short range N-N and Δ-N interactions. It is not known in fact whether these interactions will favor or disfavor a first order phase transition.

Very much delicate is also the problem of the life-time. If the nucleus were to decay by a single step the observed life time could probably be explained. The transition probability should in fact be of the order of $\left| \langle \varphi(\vec{r}_\perp, z) \mid \varphi(\vec{r}_\perp, z + d_o) \rangle \right|^{2A}$, φ being a typical single-particle wave-function,

But the life-time could be drastically reduced by a cascade decay. Due to the high degree of coherence of the σ-τ phase, however, the steps of the cascade could not be s.p. transitions. Every step should involve the rearrangement of a number of particles, and it does not appear impossible to us that such a number be so high that the life-time do not be substantially reduced.

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