# Treatment of Pionic Modes at the Nuclear Surface for Transport Descriptions *

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Using a recently developed $\pi + NN^{-1} + \Delta N^{-1}$ model [1,2], we derive dispersion relations and amplitudes for collective pionic modes for use in transport descriptions.

In-medium properties obtained in an infinite stationary system consisting of interacting nucleons, nucleon resonances and mesons, can be incorporated into transport descriptions by a local density approximation. We have obtained density dependent dispersion relations of the pionic modes, as well as density dependent amplitudes of the components constituting the pionic mode. These quantities are conveniently parametrized in terms of a few density dependent coefficients.

While such a prescription is rather straightforward to implement in the interior regions of the nuclear system, conceptual problems exist at the nuclear surface. When the nuclear density approaches zero, collective mesonic modes formed in the medium have to be converted to real particles in vacuum. The problems arise since some collective modes (*e.g.* $\Delta N^{-1}$-like) may exists in the infinite stationary system at arbitrary low (but non-vanishing) density, but no corresponding real particle exists in vacuum. It is discussed how pionic modes can be converted to real particles when penetrating the nuclear surface and how earlier treatments can be improved. When the surface is stationary only free pions emerge.

For the transport process it is not necessary to determine the character of the pionic modes until they penetrate the surface and emerge as free particles. This is automatically determined within our formalism from the amplitudes at zero density. The time-dependent situation has also been addressed.

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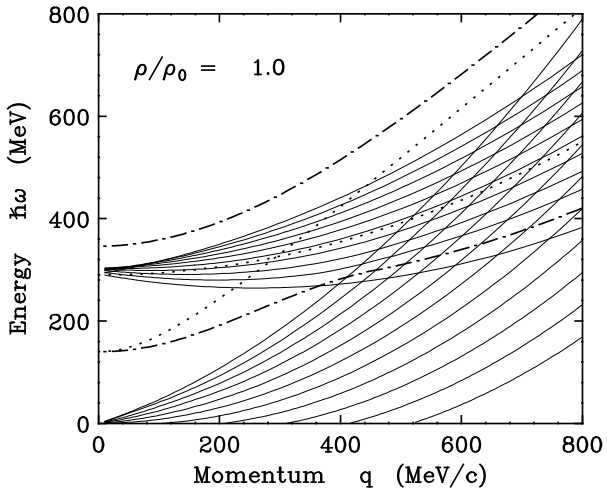


Figure 1: The dispersion relations for the spin-isospin modes in the spin-longitudinal channel, in infinite nuclear matter at normal nuclear density and for zero temperature. The non-collective modes are shown by solid curves, while the collective modes $\tilde{\pi}_1$ and $\tilde{\pi}_2$ are represented by dot-dashed curves.

We have further shown that for a stationary density profile, the conservation of the energy of the pionic mode and the partial $\Delta$ decay width combine to gurantee that only real pions are realized as free particles when the pionic mode penetrates the surface.

A simplified one-dimensional scenario is used to investigate the reflection and transmission of pionic modes at the nuclear surface. It is found that reflection of pionic modes is rather unlikely, but the process can be incorporated into transport descriptions by the use of approximate local transmission coefficients.

[1] J. Helgesson and J. Randrup, Ann. Phys. 244 (1996) 12

[2] J. Helgesson and J. Randrup, Phys. Rev. C52 (1995) 427