Klein paradox of spin wave

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Klein paradox, in its original form, referred to the greater-than-1 reflectivity of electrons incident on a potential barrier with height larger than the electron rest mass. Later, it was soon realized that the reflectivity is not a problem at all, if the correct outgoing state is selected. The real paradox is caused by the finite tunnelling probability even if the height of the potential barrier is infinite. However, there were recent suggestions for spin-wave amplification using bosonic Klein paradox. We will show that those suggestions are fundamentally flawed. For classical wave like spin wave, the probability density current used in those calculations for the reflection of spin wave is trivially conserved, which means that it is always zero for classical wave with real wave function. The reflectivity thus obtained is not correlated with the propagation of spin wave. By considering the energy transport of spin wave, we can show that, like the electron Klein paradox, there is no spin-wave Klein paradox for reflectivity, either. Heuristically, this can be understood according to the fact that, even if the ground state is unstable, any energy-carrying wave cannot have greater-than-1 reflectivity off a passive interface, which will violate the conservation of energy.

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