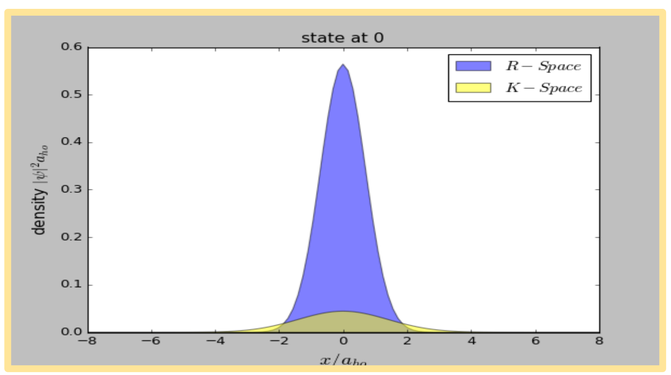
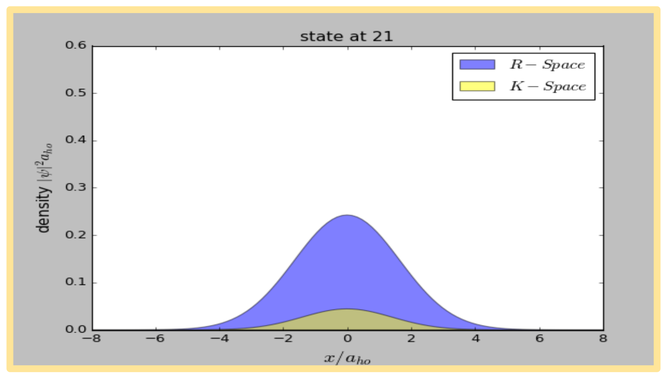
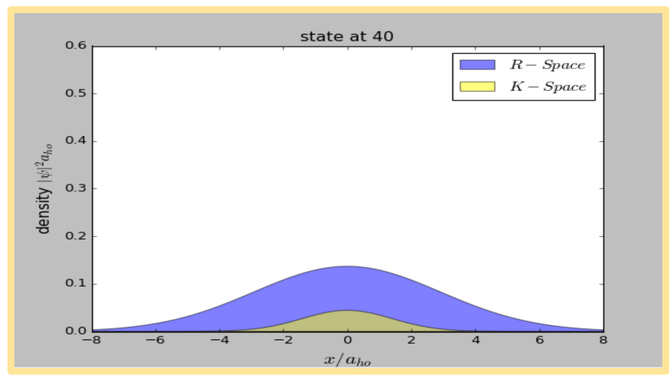
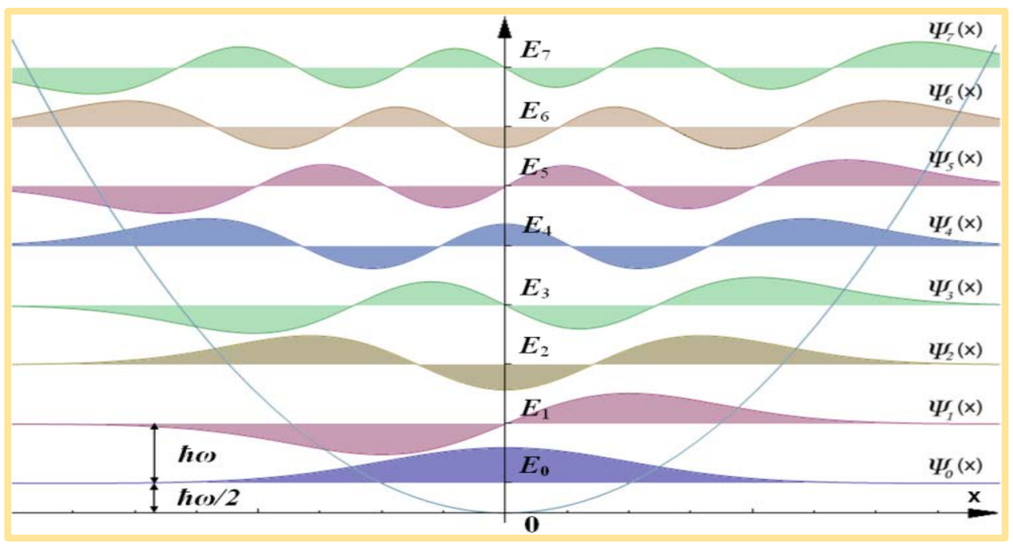
BASIC PHENOMENA IN QUANTUM MECHANICS







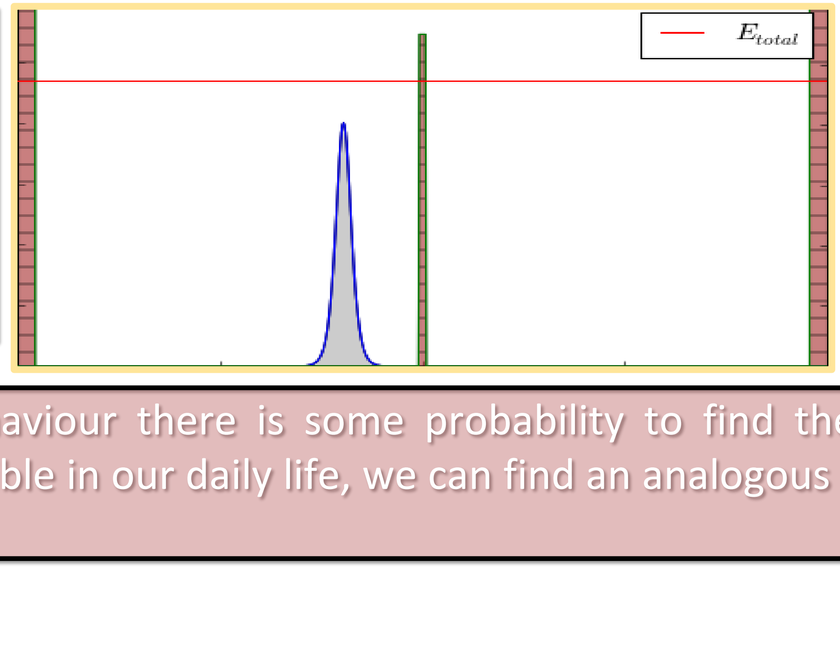
In Quantum Physics particles are described by the probabilities of being found at a certain position (blue regions in the figures) obeying the *uncertainity principle*, $\Delta x \cdot \Delta p = \hbar/2$. For instance, for a particle in a box, at the beginning this probability occupies a small region of space —we barely know where the particle is, but as time goes by, the probability spreads inside the box and we no longer know where it is. It can be observed that this phenomenon shows a clear analogy with *light dispersion*.

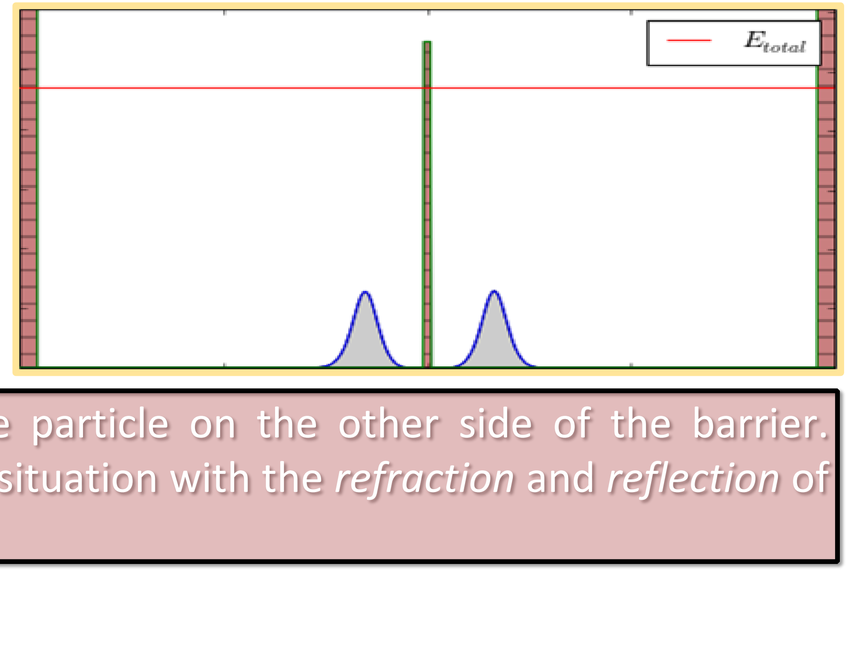


Quantum particles behave as waves but, when trapped in a harmonic potential, in general, they follow a harmonic motion. However, the system presents awesome and unexpected properties, such as the *energy quantization*.

$$E_n = \hbar\omega\left(n + \frac{1}{2}\right)$$

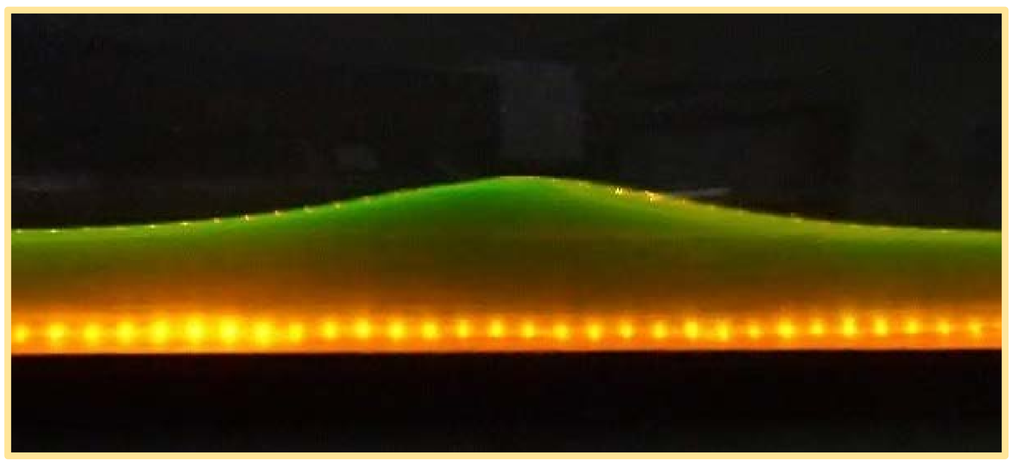
An incredible effect that appears in the quantum world is the *tunnel effect*, e.g. electrons, neutrons, etc, can escape potential barriers!





Because of its wave-like behaviour there is some probability to find the particle on the other side of the barrier. Although it may seem impossible in our daily life, we can find an analogous situation with the *refraction* and *reflection* of *light*.

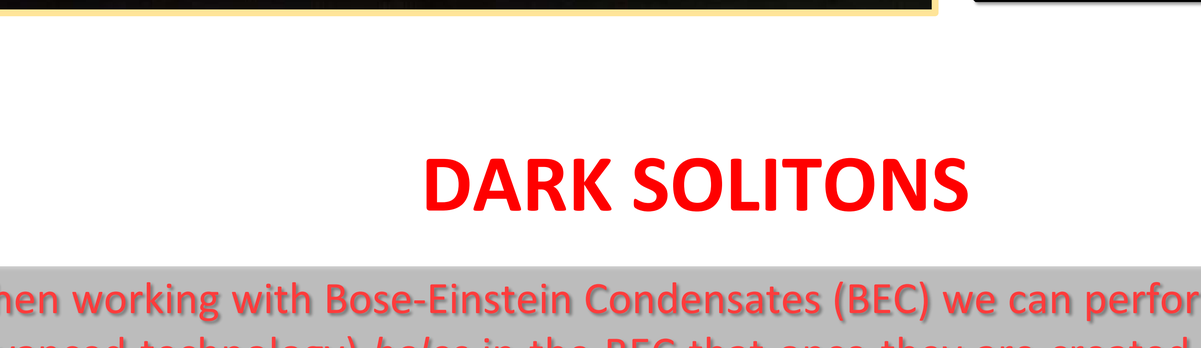
BRIGHT SOLITONS

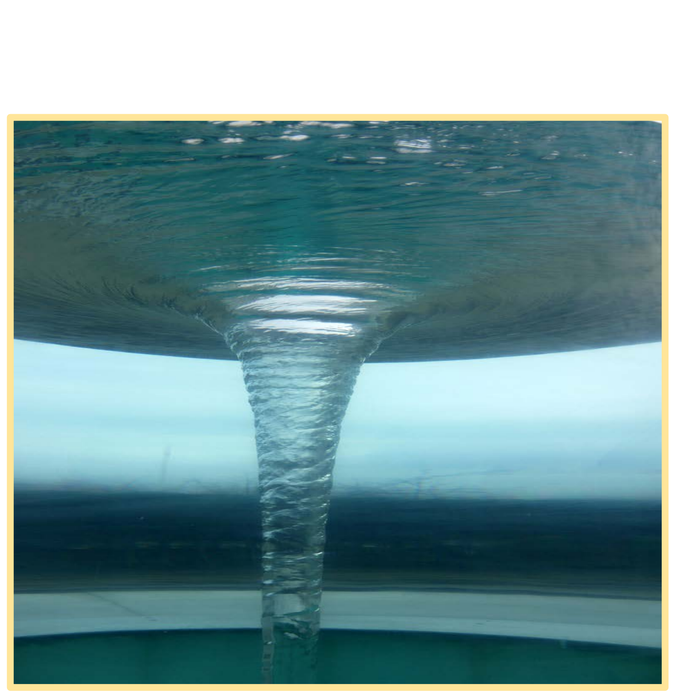


A Bright Soliton is a wave that moves in space *maintaining* its *shape*. This kind of solitons can be found in nature, for example in water. They can follow the classical dynamics —e.g. free and harmonic motions— under certain circumstances. A Bright Soliton in a Bose-Einstein Condensate is able to undergo the *tunnel effect* when facing an energy barrier.

DARK SOLITONS

When working with Bose-Einstein Condensates (BEC) we can perform (using advanced technology) *holes* in the BEC that once they are created, they do not disappear, and can be seen as a lack of matter. Those holes are called *Dark Solitons*. To understand this obscure problem we can think of the familiar situation of a vortex in water.





Dark Solitons show the same behaviour as particles and their motion can even by described by Newton's Laws with negative masses (notice that a *Dark Soliton* involves absence of matter!).

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Wavefunctions of a quantum harmonic oscillator - by AllenMcC, 2010 [public domain]. Retrieved from https://commons.wikimedia.org/wiki/File:HarmOsziFunktionen.png
Soliton - by Christophe.Finot and Kamal HAMMANI, 2009 [public domain]. Retrieved from https://en.wikipedia.org/wiki/File:Soliton_hydro.jpg
William Pye's 'Charybdis, Seaham Hall Hotel. The inner vortex - by Andrew Curtis, 2010 [public domain]. Retrieved from https://commons.wikimedia.org/wiki/File:William_Pye's_'Charybdis,_Seaham_Hall_Hotel_-_geograph.org.uk_-_1706275.jpg