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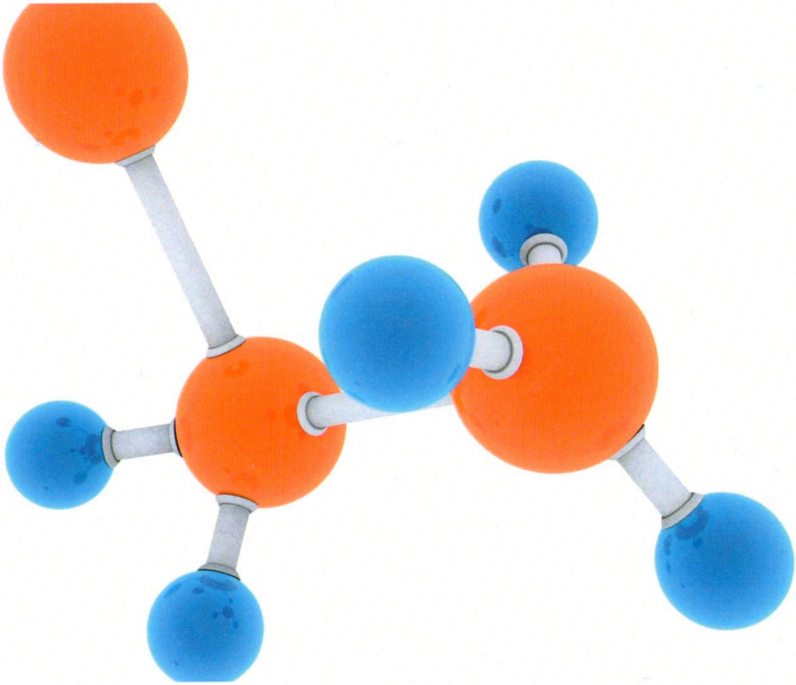

Trojan Wave Packet

Wave Packet, Atomic Nucleus, Trojan (astronomy), Lagrangian
Point, Ionic Liquid, Wigner Crystal, Bose-Einstein Condensate

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Trojan wave packet

A **Trojan wave packet** is a wave packet that is nonstationary and nonspreading. It is part of an artificially created system, which consists of a nucleus, and one or more electron wave packets, of a highly excited atom. A strong, polarized electromagnetic field, holds or "traps" each electron wave packet in an intentionally selected orbit (energy shell).[1] [2] They derive their names from the Trojan asteroids in the Sun-Jupiter system.[3] Trojan asteroids orbit around the sun in Jupiter's orbit at its Lagrangian equilibrium points L4 and L5, where they are phase-locked and protected from collision with each other, and this phenomenon is analogous to the way the wave packet is held together.

Trojan wavepacket evolution animation

Concepts and research

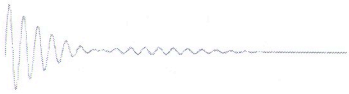
The concept of the Trojan wave packet is derived from a flourishing area of physics which manipulates atoms and ions at the atomic level creating ion traps. Ion traps allow the manipulation of atoms and are used to create new states of matter including ionic liquids, Wigner crystals and Bose-Einstein condensates.[4] This ability to manipulate the quantum properties directly is key to the real life development of applicable nanodevices such as quantum dots and microchip traps. In 2004 it was shown that it is possible to create a trap which is actually a single atom. Within the atom, the behavior of an electron can be manipulated.[5]

During experiments in 2004 using lithium atoms in an excited state, researchers were able to localize an electron in a classical orbit for 15,000 orbits (900 ns). It was neither spreading nor dispersing. This “classical atom” was synthesized by “tethering” the electron using a microwave field to which its motion is phase locked. The phase lock of the electrons in this unique atomic system is, as mentioned above, analogous to the phase locked asteroids of Jupiter's orbit.[6]

The techniques explored in this experiment are a solution to a problem that dates back to 1926. Physicists at that time realized that any initially localized wave packet will inevitably spread around the orbit of the electrons. Physicist noticed that "the wave equation is dispersive for the atomic Coulomb potential." In the 1980s several groups of researchers proved this to be true. The wave packets spread all the way around the orbits and coherently interfered with themselves. Recently the real world innovation realized with experiments such as Trojan wave packets, is localizing the wave packets, i.e., no dispersion. Applying a polarized circular EM field, at microwave frequencies, synchronized with an electron wave packet, intentionally keeps the electron wave packets in a Lagrange type orbit.[7] [8] The Trojan wave packet experiments built on previous work with lithium atoms in an excited state. These are atoms, which respond sensitively to electric and magnetic fields, have decay periods that are relatively prolonged, and electrons, which for all intents and purposes actually operate in classical orbits. The sensitivity to electric and magnetic fields is important because this allows control and response by the polarized microwave field.[9]

Beyond single electron wave packets

The next logical step is to attempt to move from single electron wave packets to more than one electron wave packet. This had already been accomplished in barium atoms, with two electron wave packets. These two were localized. However, eventually, these created dispersion after colliding near the nucleus. Another technique employed a nondispersive pair of electrons, but one of these had to have a localized orbit close to the nucleus. The nondispersive two-electron Trojan wave packets demonstration changes all that. These are the next step analogue of the one electron Trojan wave packets - and designed for excited helium atoms.[11] [12]



"In physics, a **wave packet** is a short "burst" or "envelope" of wave action that travels as a unit. A wave packet can be analyzed into, or can be synthesized from, an infinite set of component sinusoidal waves of different wavenumbers, with phases and amplitudes such that they interfere constructively only over a small region of space, and destructively elsewhere." (Quoted from Wikipedia "wave packet" article)[10]

As of July 2005, atoms with coherent, stable two-electron, nondispersing wave packets had been created. These are excited helium-like atoms, or quantum dot helium (in solid-state applications), and are atomic (quantum) analogues to the three body problem of Newton's classical physics, which includes today's astrophysics. In tandem, circularly polarized electromagnetic and magnetic fields stabilize the two electron configuration in the helium atom or the quantum dot helium (with impurity center). The stability is maintained over a broad spectrum, and because of this, the configuration of two electron wave packets is considered to be truly nondispersive. For example, with the quantum dot helium, configured for confining electrons in two spatial dimensions, there now exists a variety of trojan wave packet configurations with two electrons, and as of 2005, only one in three dimensions.

See also

- Atomic orbital
- Dispersion (optics)
- Electron wave-packet interference
- Introduction to quantum mechanics
- Ion Gel
- Quantum mechanics
- Rydberg state
- Soliton wave
- Wavelength
- Wave function
- Wave function collapse

Further reading

Books

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External links

- Glauber States (Java) [18]
- Aharonov-Bohm Oscillations In "Trojan Electrons" [19]

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[14] http://books.google.com/books?id=JDKCobIshgSIC&pg=PA93
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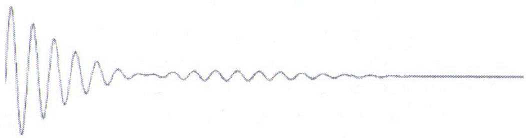
Wave packet

In physics, a **wave packet** is a short "burst" or "envelope" of wave action that travels as a unit. A wave packet can be analyzed into, or can be synthesized from, an infinite set of component sinusoidal waves of different wavenumbers, with phases and amplitudes such that they interfere constructively only over a small region of space, and destructively elsewhere.[1] Depending on the evolution equation, the wave packet's envelope may remain constant (no dispersion, see figure) or it may change (dispersion) while propagating. Quantum mechanics ascribes a special significance to the wave packet: it is interpreted to be a "probability wave" describing the probability that a particle or particles in a particular state will be measured to have a given position and momentum. It is in this way similar to the wave function.



A wave packet without dispersion.

By applying the Schrödinger equation in quantum mechanics it is possible to deduce the time evolution of a system, similar to the process of the Hamiltonian formalism in classical mechanics. The wave packet is a mathematical solution to the Schrödinger equation.[2] The square of the area under the wave packet solution is interpreted to be the probability density of finding the particle in a region. The dispersive character of solutions of the Schrödinger equation has played an important role in rejecting Schrödinger's original interpretation, and accepting the Born rule.

In the coordinate representation of the wave (such as the Cartesian coordinate system) the position of the wave is given by the position of the packet. Moreover, the narrower the spatial wave packet, and therefore the better defined the position of the wave packet, the larger the spread in the momentum of the wave. This trade-off between spread in position and spread in momentum is one example of the Heisenberg uncertainty principle.

Background

In the early 1900s it became apparent that classical mechanics had some major failings. Isaac Newton originally proposed the idea that light came in discrete packets which he called "corpuscles", but the wave-like behavior of many light phenomena quickly led scientists to favor a wave description of electromagnetism. It wasn't until the 1930s that the particle nature of light really began to be widely accepted in physics. The development of quantum mechanics — and its success at explaining confusing experimental results — was at the foundation of this acceptance.

One of the most important concepts in the formulation of quantum mechanics is the idea that light comes in discrete bundles called photons. The energy of light is a discrete function of frequency:

$$E = nhf$$