ENERGY PRODUCTION IN COMPRESSED MATTER

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Abstract

This paper notes that the dispersion relation $\nabla p_x \nabla x \geq \hbar/2$, when expressed as an equality, $\nabla p_x \nabla x = \hbar/2$, defines the relationship between the ground-state mean kinetic energy of a confined quantum, and its dimensions of containment. The containment can occur in two ways: the first by an attractive potential, and the second by a repulsive potential. If the quantum is bound by an attractive potential, the ground-state kinetic energy is balanced by the containing potential in a stable state where the kinetic energy remains within the bound system. In the second type, which is only possible by compression, the quantum is contained by collisions with the bounding potential, which may result in a transfer of kinetic energy to the boundary. If the boundary is sufficiently massive, then the energy transfer will have a negligible effect on the dimensions of containment, and therefore the ground-state kinetic energy of the contained quantum will not significantly change. This energy transfer could be large. An electron contained within the approximate diameter of an iron atom, 250 pm, for example, would have a minimum velocity very great compared to the dimension of containment, so that the number of collisions per second with the boundary would be very high, on the order of 10^{15}. An exchange of only 10^{-6} ev per collision would produce 10^{9} ev per second of energy transmitted to the boundary.

Keywords: Uncertainty Principle, energy, conjugate Fourier variables, energy production, energy non-conservation, non-locality.

The dispersion relation between the conjugate Fourier variables of position and momentum,

$$\nabla p_x \nabla x \geq \hbar/2, \qquad (1)$$

as developed by [1,2], cannot be regarded as merely a statistical relationship expressing an uncertainty in repeated measurements of the same variable. For a single quantum, represented by a wave function $\psi(x)$, located with 100% probability within a region along the x-axis between x = 0 and x = d (that is, for $0 \geq x \geq d$, $\psi(x) = 0$, and for $0 < x < d$, $\psi(x)$ is normalized at 100%), then (1) expressed as an equality,

$$\nabla p_x \nabla x = \hbar/2, \qquad (2)$$

must represent the relationship between the ground-state rms momentum of the quantum, which defines its ground-state mean kinetic energy, $(\nabla p)^2/2m$, and the magnitude of the dimension of containment, d.

The containment can occur in two ways. The first is by an attractive potential, V(x), whose source is located at x=0, such that for $x \geq d$, the value of $\psi(x)$, is negligible. The second is by repulsive potentials at x = 0 and x = d, such that the probability of the quantum being in the region $0 < x < d$ is 100%, and outside of it zero. In the first case, the total energy of the system, that is, the kinetic energy of the quantum plus the potential energy in the interval d, is given by the Schrödinger expression for the Hamiltonian:

$$E\Psi(x) = (-\hbar/2m)\, d^2\Psi(x)/dx^2 - V(x)\Psi(x), \;\; x > 0. \qquad (3)$$

In the second case, the Schrödinger equation gives

$$E\Psi(x) = (-\hbar/2m)\, d^2\Psi(x)/dx^2, \quad 0 < x < d, \qquad (4)$$

and

$$E\Psi(x) = 0, \quad 0 \geq x \geq d.$$

Here the total energy eigenvalues are the kinetic energy eigenvalues, determined by the magnitude of the momentum,

$$p = h/\lambda, \qquad \lambda = d/n \quad (n = 1,2,...) \qquad (5)$$

In this case, (2) is non-local and non-conservative. That is, a change in the magnitude of the containment distance from d to $d \pm \delta d$ changes the energy eigenvalue spectrum, and in particular the ground-state mean kinetic energy determined by (2) from $K = (\hbar/2d)^2/2m$ to $K' = (\hbar/2(d\pm \delta d))^2/2m$ in the entire region of containment. This change of energy values is solely a function of δd for a given d and m, and is independent of any energy from the region $0 > x > d$ required to change the position of the boundaries. (It is interesting to note that the minimum rms momentum given by (1) is less than the minimum momentum allowed by the de Broglie relation (5) by a factor of $1/4\pi$.)

It seems to me that both types of containment coexist in nature, but one type will generally determine the greater degree of containment, and therefore predominate. For example, in a normal solid, the atomic electrons are bound relatively strongly by the attractive potential of the nucleus, and relatively weakly by the repulsive potentials of the electron clouds of adjacent atoms. Therefore the first type of containment dominates. If however, the solid is compressed enough so that the interatomic dimensions shrink sufficiently for the adjacent electron clouds to impose a repulsive boundary less than the dimensions of the uncompressed atom, then at some point, the ground-state kinetic energy from the repulsive boundaries will exceed that from the attractive potential of the nucleus for some electrons, and one or more electrons will effectively act as free electrons bound by the adjacent electron clouds, and will begin colliding with them, thereby transmitting kinetic energy to the lattice.

Consider an electron bound by two large, narrow repulsive potentials at $x = 0$ and $x = d$, where $d = 2.5 \times 10^{-10}$ meter, the approximate diameter of an iron atom. Since $\nabla p = m_e v_{rms}$, where m_e is the mass of the electron, and v_{rms} is the rms velocity of the electron, then (2) would become

$$m_e v_{rms}\, d = \hbar/2, \tag{6}$$

so that $v_{rms} = \hbar/2m_e d$. Using $\hbar = 10^{-34}$ J-s, and $m_e = 9\text{x}10^{-31}$ kg, we get $v_{rms} = 2.22 \times 10^5$ meters/sec. Using $d = 2.5 \times 10^{-10}$ meters, this gives approximately 10^{15} per second for the number of transits of the bound interval, d, and therefore the rate of collision of the electron with the boundary. Even a very small transfer of only 10^{-6} ev per collision would give a total transfer of energy to the boundaries of 10^9 ev per second. However, since the ground state mean kinetic energy of an electron contained within the dimensions of this size would only be approximately .14 ev, and since the binding energy of the outer iron electron is about 50 ev, or even 10 ev for zinc, the amount of compression required to make the transition from the first type of containment to the second would seem very great, perhaps only occurring in the interior of very massive objects.

But this suggests that the source of heat in the interior of such objects may not only be nuclear fusion, but also energy generated by the compression of the contained matter by the intense force at their centers. If so, then one might speculate that at some size, the dimensions and composition of the object would produce an inability to transmit thermal energy sufficiently rapidly from its interior, resulting in instabilities that would produce a continual explosive ejection of surface layers from it.

In this case, galaxies might represent not only a condensation of diffuse matter, but also an evolutionary stage reflecting matter constantly being ejected from the surface of a very massive core. Presumably then, very small, compact objects, whose ejection process had not yet begun and so had no surrounding cloud of relatively dense matter to mask their high gravitational red-shift, would represent precursors to this expansive stage--that is, very young pre-galaxies.

But even though the transition from the first type of containment to the second for atomic electrons only appears possible under compressions not achievable in the laboratory, nonetheless it seems to me that since the atom itself may act as a quantum within the lattice structure of a solid, such a transition of the atoms themselves may be possible under lower compressions.

[1] Kennard, E. H., Zur Quantenmechanik einfacher Bewegungstypen, *Zeitschrift für Physik* **44** (4–5) (1927) 326.

[2] Heisenberg, W., Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik, *Zeitschrift für Physik* **43** (3–4) (1927) 172–198.