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Could Exotic Matter Provide an Infinite Source of Energy?

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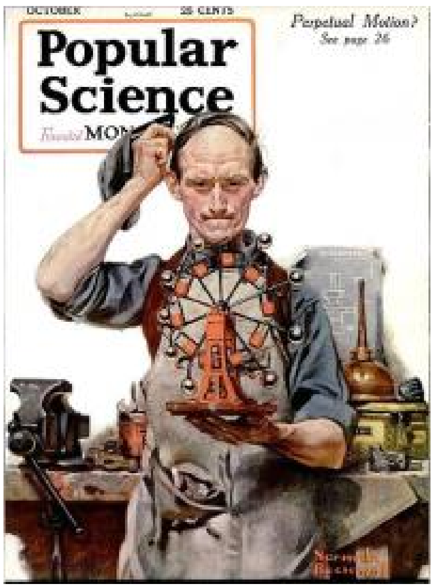

Cover of the October 1920 issue of Popular Science magazine, painted by American illustrator Norman Rockwell. It depicts an inventor working on a perpetual motion machine.

(PhysOrg.com) -- Generally, scientists prefer to avoid the concept of perpetual motion. The idea of a machine that could produce movement that goes on forever, and using that movement to generate an endless stream of energy, is usually considered more science fiction than science. But recently, physicist Pavel Ivanov has investigated previous speculation that an exotic fluid with unusual properties could cause energy to flow continuously between different regions of space, resulting in a runaway transfer of energy. If an advanced civilization were able to construct a device to capture this energy, it might finally possess its own "perpetuum mobile" -- or perpetual motion.

Ivanov, from both the University of Cambridge and the Lebedev Physical Institute in Moscow, has analyzed this possibility in a study accepted to *Physics Letters B*. The idea is that a one-dimensional exotic fluid, whose unique properties such as violating the weak energy condition in particle physics, leads to a scenario in which there is a light cone with regions of negative and positive total energies. Ivanov has calculated the equations of state which give a continuous energy transfer from the negative regions to the positive regions, resulting in what he calls "perpetuum mobile of the third kind." However, Ivanov conjectures that theories "plagued" by solutions involving continuous energy flows should be discarded as inherently unstable.

The concept of exotic matter - matter that violates certain physical laws - is not new. Exotic matter is at the basis of many intriguing theoretical possibilities, such as wormholes, time machines, and even so-called cosmological doomsday models of the universe in which the universe's energy density continually increases. Here, Ivanov shows that, in a class of models containing a certain kind of exotic matter, there could be ever-expanding regions of space with positive and negative total energies. Since the absolute values of the energies in both these regions grow indefinitely with time, the energy of the whole physical system is conserved.

"In the setting outlined in the paper, the perpetuum motion is a new effect, as far as I am aware of," Ivanov told *PhysOrg.com*. "But the number of published papers on exotic matter is quite large, and therefore, there could be some papers on this unknown to me.

"There are so-called cosmological doomsday solutions where an expanding spatially homogeneous universe filled by an exotic matter evolves in such a way that the density, and accordingly, the energy density, grows with time," he explained. "The energy density may even grow infinite during a finite period of time - the effect dubbed 'the cosmological doomsday.' However, the notion of total energy is, in general, rather ambiguous for the universe as a whole, and in any case one should accurately define and use the energy associated with a gravitational field when considering cosmological solutions, so in this case it is not clear (for me, at least) whether this situation may be called 'perpetuum motion' or not. In my case, the fluid expands in a flat space-time, where the notion of energy is well defined, so one can use standard definitions to classify solutions."

In one variant of the model, a region of space filled with exotic matter could have a total energy that decreases indefinitely with time. This decrease could be due to hydrodynamical effects (from the moving exotic liquid itself), or it could be due to interactions with a conventional physical field carrying positive energy, such as gravitational waves. In such a case, the gravitational waves would be continually carrying away positive energy from the region, resulting in a runaway energy transfer. One possible physical model of this activity might be exotic matter concentrated on a one-dimensional line in three dimensional space, so that the one-dimensional motion of the line could produce gravitational waves that carry away positive energy from the system.

As Ivanov explains, this situation resembles the action of a perpetuum mobile of the second kind, where heat is transferred from a colder part to a hotter part of an isolated system. However, because the situation Ivanov investigates doesn't deal with temperature, he refers to the hypothetical effect as a perpetuum mobile of the third kind.

Ivanov points out that, although it may be technically difficult to construct the runaway process involving the emission of gravitational waves, it may be easier to construct a process with even more exotic "ghost" matter, which has a negative energy density. For example, he considers a model of a rotating relativistic string with two monopoles at its ends emitting weak gravitational waves. With modifications, this model can be converted to a model of "ghost" matter interacting with gravity, with the length of the rotating string ever increasing with time, thus making the total energy of the string-monopoles system ever decreasing. The positive energy carried away by gravitational waves might be captured by an advanced civilization and put to whatever use they might have for it.

"I personally think that the emergence of perpetual motion in a theory may pose a difficulty for the theory, since this leads to infinite concentration of energy in some regions of space, which is dangerous," Ivanov said. "Also, quite subjectively, I dislike the theories operating with fluids violating the weak energy condition; they contradict to my aesthetic feeling. Of course, this quite subjective point of view may or may not be correct."

More information: Pavel Ivanov. "On the dynamics of exotic matter: towards creation of Perpetuum Mobile of the third kind." To be published in *Physics Letters B.* Available at arxiv.org/abs/0909.0190 .