Journal of Scientific Exploration, Vol. 21, No. 3, 572–594, 2007 0892-3310/07

LETTERS TO THE EDITOR

What is Potential? Arp responds to Ibison

In *JSE* 21, no. 1, pages 219–223, Michael Ibison gives a helpfully lucid explanation of the problem of instantaneous communication in General Relativity. The crux of the matter seems to be "... gauge (which relates potentials to forces)." And then "... potentials propagate at light speed but forces remain pointing towards the instantaneous position."

It would seem that, in order for the potential to yield a force which points to an instantaneous position, it would have to receive information instantaneously. But that is forbidden in General Relativity. For me, defining potential as something that gives you the right answer is not satisfactory. What is potential? Is it energy? Matter? Or is it a mathematical symbol when differentiated yields another intangible quantity that is supposed to explain the "pulling toward each other" observed in physical bodies?

Mathematics I think is even more prone than physics to the tendency to give observations a name or symbol and then advertise that a phenomenon has been explained.

HALTON ARP
Max-Planck-Institut fuer Astrophysik
Garching, Germany
arp@mpa-garching.mpg.de

Response to Halton Arp's Comments and Tom Van Flandern's Published Position on the Reality of the Electromagnetic and Gravitational Potentials

In *JSE* issue 21, number 2 (p. 435), Halton Arp questions our understanding of the potentials used to compute gravitational forces. At the expense of taking up more space, I will try to respond in a manner that hopefully will be accessible to the broader readership.

It will be necessary to distinguish between two quite different uses of the word 'potential' in physics. Associated with a compressed spring, for example, there is a *mechanical* potential energy. The spring, if released, will deliver a force causing whatever masses are attached to accelerate. This kind of potential energy can be traced to internal stresses in the system. When it is allowed to accelerate a mass, the potential energy is converted into kinetic energy. Note that all known laws of physics require, for their articulation, a distinction between potential and kinetic energy. These two types of energy are equally 'real'. For example, both have mass—both of them can be weighed.

The word 'potential' is also used in physics to describe a state of affairs in the continuum of space induced by an electric charge or a gravitating mass, and this is the kind of potential that will now be considered. This potential by itself is not an energy, has no mass, and cannot be weighed. The potential at some location in space refers instead to the energy that *would* result, *if* a ('test') charge or mass were present at that location. One might say that it is a 'potential *for* energy'. Accordingly, the electromagnetic and gravitational potentials are mathematical tools used to convey the (potential) influence of source charges and masses sources on distant test charges and masses. Hence the concept associated with this use of the word is more abstract than in the mechanical case. Except in special Aharonov-Bohm type configurations, these potentials cannot be measured directly. Mostly, their influence is known only indirectly through the force they exert on test masses. (Since a test charge or mass at some location has an energy given by the potential, it immediately follows that there is a force on any such particle in the event that there is a gradient in the potential.)

The continuum potentials have another quality. Though the potentials are not themselves measures of some internal energy, the square of their gradients is an energy in its own right, independent of the presence or absence of test charges and masses. These gradients propagate, like waves, at light speed.

The above is an abbreviated description of the potentials as understood by the mainstream, as they are employed in the Maxwell theory of EM and the weak-field limit of GR—Einstein's theory of gravity. Observe that the mainstream conception accords the potentials both an abstract nature—as an conveyor of distant influences—and a more tangible nature—as repository of energy in whatever gradients are present.

There are two 'non-mainstream' schools of thought that contest this dual nature of the potential. The 'Lorentzian Relativists', of which Tom van Flandern is one, would deny the role of potentials as abstract conveyors of distant influence. Instead, the existing mathematical machinery is given a different interpretation whereby the potentials connote activity in a material–mechanical–aether that is present in all space. Their position effectively removes the distinction between the mechanical potential described above, and the continuum potentials of EM and GR. One of the tasks for the adherents of this interpretation is to marry the expected energy of the classical plenum with observation (for instance in accord with evolution of the Cosmological scale factor of the Robertson-Walker metric).

The author of this note is sympathetic to another school of thought, which accepts the role of potential as abstract conveyor of distant influence, and contests instead the ability of potentials to carry any energy of their own (in the form of gradients). This is called the 'direct-action' interpretation of EM and gravitation. (The word interpretation is being used loosely here. Direct-action connotes a modification to the mathematics, specifically the boundary conditions, in the theories of Maxwell and Einstein.) In this interpretation, the energy that is conventionally attributed to the gradients in the potentials is re-assigned to the energy of interaction resulting from their role as conveyors of distant influences. It may be inferred that, in order for this to work, it is absolutely mandatory that all radiation is absorbed. One of the tasks for the adherents therefore is to marry the prediction of that theory that all radiation is in fact interaction, with the observation that nearly all starlight is destined never to interact with matter. This issue was addressed by Wheeler and Feynman in their 1945 [1] and 1949 [2] papers, and taken up more recently by Hoyle and Narlikar [3], and others (though the subject goes back more than 100 years to the work of Schwarzschild, Tetrode, and Fokker). For a long time there was no satisfactory resolution (see for example Davies [4] for a thorough review), leading the mainstream to reject direct-action. Recently however, the author [5] has argued that the (accepted) mathematics describing the Cosmological expansion permits an interpretation that meets the so called Wheeler-Feynman boundary condition in another way. Very briefly, it asserts that Cosmological red-shift can be interpreted as the signature of absorption by the Cosmological gravitational field (appropriately defined). Consequently, all radiation is destined to be absorbed and therefore the direct-action theory is viable after all. That is, the potentials are exclusively conveyors of distant influences, and have no intrinsic energy.

Though I am probably in agreement with Halton Arp on doubting that the continuum potentials have intrinsic energy, I differ with both Halton and Tom van Flandern on the need to break with the mainstream to assert superluminal propagation of force. It is my view that there is no contradiction between potentials that move at finite (light) speed, and the existence of non-aberrated forces that point to or away from the instantaneous location of a moving source. In EM and GR the potentials and forces propagate at light speed. The fact that the direction of the force is not constrained to be parallel to the direction of propagation is sufficient to explain the 'apparently instantaneous connection' in the special case of uniform motion. I will admit there *is* a paradox *if* one chooses to think of forces as resulting from collisions with spinless particles. But that view is incompatible with the mathematics of EM and GR, and not one I find attractive.

Michael Ibison
Institute for Advanced Studies at
Austin, Texas, USA
ibison@earthtech.org

Bibliography

1. J. A. Wheeler and R. P. Feynman, ''Interaction with the absorber as the mechanism of radiation,'' *Rev. Mod. Phys.*, vol. 17, no. 2 and 3, pp. 157–181, 1945.
2. J. A. Wheeler and R. P. Feynman, ''Classical electrodynamics in terms of direct interparticle action,'' *Rev. Mod. Phys.*, vol. 21, no. 3, pp. 425–433, 1949.
3. F. Hoyle and J. V. Narlikar, *Action at a Distance in Physics and Cosmology*. San Francisco: W. H. Freeman, 1974.
4. P. C. W. Davies, *The Physics of Time Asymmetry*, 1st ed. Berkeley, CA: University of California Press, 1977.
5. M. Ibison, ''Are Advanced Potentials Anomalous? in Frontiers of Time: Retrocausation–Experiment and Theory,'' in *AIP Conference Proceedings,* 863 ed. D. P. Sheehan, Ed. Melville, New York: AIP, 2006, pp. 3–19.