Why bring back the aether?

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First of all, let's be clear that by the term "aether" (sometimes confusingly spelled as "ether"), we do not mean a new form of matter. Rather, the aether is simply another name for the "vacuum" or "space" which is assumed not to be empty or void but to have physical properties that enable the existence of matter and determine its physical properties.

The motivation for considering the existence of an aether may be summed up in one simple question:

Why is the equation for waves on a string Lorentz-covariant?

The answer obviously does not begin with Einstein's postulate that differently moving observers measure a single, constant speed of waves on a string (or light in a vacuum). Yet the only theoretical restriction imposed by the special theory of relativity is that equations of matter be Lorentz-covariant. So anyone looking for a theory of matter should ask, "How can I derive a Lorentz-covariant theory?" or "Where do Lorentz-covariant theories come from?" The obvious answer is that Lorentz covariance is a property of waves in Galilean space-time, with the key property being a linear relationship between the curvature (or Laplacian) and the second time derivative of a field describing the perturbation.

As far as special relativity goes, an interpretation of matter as waves in a deformable medium offers an explanation for Einstein's postulate: differently moving observers must use waves to make their measurements. Since these waves propagate at the same speed as light, it is impossible to make an independent measurement of the actual speed of light. In other words, all measurements of length are equivalent to measuring light propagation time, and the speed of light is reduced to a conversion factor between the units of time and length. This fact is acknowledged by the modern definition of the meter as the distance light travels in $(1/c)$ seconds. Hence with aether theory, special relativity is a derived property of measurements rather than an a posteriori principle invented to explain experimental observations.

Of course, there is more to physics than special relativity. A successful theory of matter must also explain the quantum behavior of particles and gravity. Gravity is easily understood in terms of an aether, since general relativity attributes physical properties (such as curvature) to empty space. Many authors have interpreted gravity as being equivalent to wave refraction in a variable medium. Einstein himself wrote, "According to the general theory of relativity, space without ether is unthinkable."

The main shortcoming of aether theory has been the lack of a mechanistic explanation of quantum mechanics. With the statistical successes of successive quantum theories, physicists have almost completely abandoned attempts to formulate a mechanistic theory for the behavior of matter. Yet the absence of a mechanistic theory only means that such a theory has not been found (as Carl Sagan once said, "lack of proof is not proof of lack"). There is no reason to think that such a theory is not possible. Indeed, recent developments offer promise that such a theory may be imminent.

Books on quantum mechanics often point out that the theory explains phenomena that had not previously been explained by classical physics. This is true. But one should ask *why* classical physics failed to explain these phenomena. Was it because classical models are intrinsically ill-suited to describing nature? Or was it because realistic classical models were too complicated for physicists to analyze?

The historical evidence points to the latter explanation. The earliest conception of the aether consistent with the behavior of light waves was Thomas Young's observation that light seemed to behave like transverse waves in an elastic solid. This theory was successfully applied to the study of light by a host of now-famous 19^{th} century scientists, with contributions from Boussinesq, Cauchy, Fresnel, Green, MacCullagh, Navier, Stokes, Rayleigh, Riemann, Thompson (Lord Kelvin), and others (Maxwell used a more complicated aether model to derive the equations of electromagnetism). Yet in spite of the elastic solid's conceptual simplicity, and the extensive effort spent analyzing it, no exact description of its physical behavior could be produced. The reason for this failure is the non-Abelian nature of finite rotations. Nineteenth-century scientists did not have the mathematical tools needed to describe arbitrary variations of orientation, and even modern condensed matter theorists have shied away from the attempt (Kleinert 1989).

Today, the mathematics of rotations is well-understood for quantum mechanical systems. This fact makes it reasonable to suppose that rotations in classical elastic solids might also be described by similar mathematics, thereby removing the main barrier to successful analysis of classical aether models. Understanding of such classical systems is also relevant to other fields such as mechanical engineering and materials science. Other theories of elementary particles are not likely to have broad application to macroscopic systems.

One last question is whether or not a successful aether theory would be an improvement over the Standard Model of particle physics. The answer is clearly "yes." Since the Standard Model was built by deconstructing experimental data, it relies on twenty or more empirical constants that have defied any unifying explanation. An aether theory, if successful, would provide a derivation of all physical parameters from as few as three fundamental constants. In the case of an ideal elastic solid aether, these would be, e.g., inertial density, bulk modulus, and shear modulus.

The above discussion explains the motivations for research into aether models of the universe. This research has led to some recent successes, which may provide further inspiration:

1. Interpretation of the gauge structure of the standard model in terms of motion in a lattice of elastic cells (Schmeltzer 2009).
2. Derivation of quantum mechanical energy, momentum, angular momentum, and correlation operators associated with rotational soliton waves in an elastic solid (Close 2010a).
3. Explanation of spatial reflection in terms of known particles using a new geometry-based parity operator (Close 2010b).

References:

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