Even More Relativity

In the continuing pursuit of ever more satisfactory answers to scientific questions, it is occasionally useful to step back and ask some fundamental questions all over again. In a time of superstring and ten-dimensional hypothetical solutions, such an inquiry seems overdue in theoretical physics.

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Asking Different Questions

Quicker scientific progress is sometimes achieved by reasking, from a different angle, those questions that have been maddeningly difficult to answer coherently. One could, for example, strive forever to find precise definitions for the concepts of hot and cold based on the ancient assumption that they are opposites. Eliminating that perceptual assumption, however, has lead to conceiving of hot and cold as different degrees of one concept: temperature - the internal motion of an object. The effectiveness of that revised approach is confirmed by its clarification of why the useful, but less comprehensive, conclusion that hot and cold are opposites had arisen in the first place: that our own bodily temperature had provided the base from which we looked (in what appeared to us to be obviously opposite directions) at the temperatures of other objects.

This search for more fundamental concepts in the pursuit of ever more coherent and comprehensive explanations has been, and will continue to be, one of the most effective methods for bringing fresh perspectives to scientific inquiries. Operating on that assumption, and applying that research method to the relationship of mass and energy, the characteristics of fundamental particles, the source of the uncertainty principle and the nature of the speed of light, also produce a different perspective with which to view the universe, a perspective based on even more relativity.

Taking the Next Step

Albert Einstein's relativity theories took us one step away from classical mechanics, in which mass and energy were considered different and unique substances, by describing the formula by which each can be converted into the other ($E=mc^2$). Such demonstrated convertibility is a clue that there may be a common basis to both mass and energy, just as the convertibility of solid ice into liquid water, and vice versa, is a clue that there is one basis (H_2O) for both water and ice.

But it has been difficult to dismiss outright our perceptual bias in favor of mass, as it is mass that we see all around us. It's the real stuff we can touch and see and smell. It looks more real to us than energy (even more real than the visible light supplying us with most of these perceptions) because mass has about the same relative velocity that we do.

We are, in effect, velocity chauvinists.

We have assumed that we are at rest, that our usual velocity is zero (an assumption not far removed from the belief that we are the center of the universe), and that what is at rest with respect to us (mass) is the basic reality of existence. Pure energy, on the other hand, moves at, or almost at, the speed of light and is therefore assumed to be less substantial.

But physicists have overcome this perceptual bias. We are scientifically convinced that only a very small portion of those heavy masses we see around us are actually at rest (that is, have no relative velocity) with respect to us. Mass is apparently just energy trapped within a structure, and that structure is what appears to us to be at rest.

So modern physicists measure mass as just another form of energy and continually refine their theoretical attempts to make the concept of mass a subset of the concept of energy. But after decades of such attempts, the difficulties of devising a universal field theory have not been overcome.

There is a different step that can be taken, though, and that is to view both mass and energy as subsets of yet another concept, one that has been ignored for most of this century.

Relativity of Mass and Energy

The evidence supporting the essentially relative nature of mass and energy is abundant. Measurements of both mass and energy have been shown to be relative to the motion of the measurer. In the case of mass, the measurer's relative velocity with respect to an object affects the amount of mass that object appears to have. In the case of energy, light is effectively made more energetic ("blue-shifted") if the measurer is moving towards the source of light (or if that source is moving towards the measurer), and light is effectively made less energetic ("red-shifted") if the measurer is moving away from the source of light (or if that source is moving away from the measurer).

It is also known that the mass of a moving electron is greater than the mass of an electron at rest. An electron always gains weight (increases its mass) as it accelerates towards the speed of light.

Scientists do still speak of mass as being "liberated" as energy, or as being "converted" into energy, during the process of detonating a nuclear weapon. But they also assume that energy and mass are actually equivalent, since mass can be reduced to packets of energy.

That assumption, though, provokes essentially the same fundamental question: how do you hold the universe still in order to discover what parts of it are mass and what parts are energy?

Since the universe can't be held still, and since it depends completely on the reference point you choose as to what in the universe constitutes mass and what constitutes energy, and since no matter what reference point you might choose to use, another reference point yielding different answers can always be chosen, there is no real answer to the questions what is mass and what is energy. It amounts to the same thing as asking what is hot and what is cold.

When the concepts being measured are both relative to each other and based on the viewpoint of the measurer, such questions can never be definitively answered. And such relative concepts can't be fundamental ones.

Currently the attempts to answer the unanswerable focus on energy as the sole reality. Albert Einstein initially felt that intense concentrations of energy had to be described in terms of mass, and that all lesser concentrations of energy could be described in terms of field theory. Through continual refinements, though, ever more intense concentrations of energy could be described in terms of field theory. This led to many attempts, including Einstein's, to construct a pure field theory which would explain everything in terms of energy. But these theories always break down in the most highly concentrated energy locations (that is, wherever mass is).

Although it is intriguing to attempt to explain the effects of a car crash at the Indy 500 by a series of tumbling, destructive, energetic impulses, emanating from the course of the field, and although it might even be a good way to describe a car crash, a far less complicated theory can also be devised, one that pays more attention to those high concentrations of energy which keep a successful pure field theory just out of reach.

Since relativity theory is now thoroughly established as an undeniably effective tool for analyzing the world around us, it might even be a good time to reconsider an ancient Greek theory in this new light, even though, as part of the advance of relativity theory itself, that ancient theory appears to have been discredited earlier this century.

The lingering popularity of Democritus's atomic theory floundered when the atom was found to be destructible, not indestructible as he had predicted. The destructive force of atomic weapons made it devastatingly obvious that atoms can be destroyed. But what seems to have been ignored by almost everyone is that

Democritus never argued that his theoretically indestructible atoms were the basic components of molecules.

Decades ago, after it was discovered that there were over 100 types of these molecular constituents, and that they could be ripped apart into their own constituent parts (protons, neutrons and electrons), it was concluded that the atom is neither indivisible nor indestructible, when it should have been concluded that the constituent parts of molecules are not really atoms.

Democritus's atom might still be awaiting our discovery.

Although the search for fundamental particles has continued, the methods currently being used, and the ever higher energies required for such methods, make a quick arrival at an effective answer unlikely.

To accelerate this process, then, we need to ask what the characteristics of true indestructibility would be.

As the ancient Greek atomists argued, a real atom would have to be indivisible. It could not have any parts, much less any moving parts. That means a real atom could not have a temperature. It would have no internal motion. It could be neither cooled nor heated (the internal motion could not be slowed down or sped up because there would be no internal motion). Since its internal motions could not be increased, a real atom could never explode. It could never be destroyed. And not having parts, it could never be put together. Indestructibility entails inconstructibility.

Such an indestructible, inconstructible atom, if it exists, would be **the** fundamental particle.

So how would such an odd object react to an input of energy?

That energy would have to be used by the atom externally, as velocity or spin, not internally as heat. If you tried to heat up a real atom, it would soon be either rushing away from your vicinity, having used the energy to accelerate its own relative velocity, or spinning more rapidly, or both.

Only such a fundamental particle (obviously extremely small) would have no internal velocity no matter what its external velocity. And that is the characteristic trait that will let us know we have arrived at Democritus's atom: all its energy (relative to us) will be expressed in terms of its external velocity.

That means that a real atom would appear to be mass to an observer whenever that atom's relative velocity with respect to that observer was zero, and a real atom would appear ever more energetic to an observer the greater that atom's relative velocity with respect to that observer was.

That also means that the existence of real atoms would provide the conceptual link underlying the relative concepts of mass and energy.

Fortunately, clues to the existence of this truly indestructible atom have already been piling up, under different guises. One pivotal clue was described almost 100 years ago. It is Planck's constant.

The New Atom

Discreteness is one characteristic element of indestructibility. An indestructible object, when observed individually (that is, without respect to its functions as part of a cluster of such objects), should always appear to be an individual clump and should never behave as a continuum.

Almost all familiar objects act somewhat discretely and somewhat as a continuum. Studying those objects which act with the most discreteness should help point the way to an indestructible object, if one exists.

One potentially fruitful source of study is the photon. Photons often are perceived *en masse*, and therefore appear more like a continuum, but individual photons behave with a high degree of discreteness. The addition of just one photon to an atom causes an electron to make a quantum jump in its relationship with the nucleus of that atom.

The behavior of other subatomic particles also includes such abrupt quantum jumps. And all such quantum behavior can be expressed mathematically as a function of Planck's constant.

Max Planck announced the discovery of his new constant (given the symbol h), which completed his formula: $E=h\nu$, in 1900 (ν is the symbol for frequency). He devised this formula to explain why light is first released at lower frequencies, rather than over the entire spectrum of frequencies, as had been expected. This discontinuity in energy was strikingly peculiar to Planck, but unavoidable. It left turn-of-the-century scientists with a formula that could be demonstrated as accurate, but no way of visualizing what was happening.