

What Is Energy?

A Four-Spatial Interpretation in World–Universe Cosmology

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Abstract

Energy is one of the most fundamental physical parameters. It can be measured, transferred, transformed, and conserved with extraordinary precision. Nevertheless, these properties do not by themselves answer a more fundamental question: **What is energy physically?**

World–Universe Cosmology (WUC) proposes an answer based on the four-spatial-dimensional structure of the World. In WUC, the World is a finite, boundless three-dimensional Hypersphere that forms the surface of an expanding four-dimensional Nucleus embedded in the Eternal Universe. The Nucleus expands in the fourth spatial dimension with the fundamental speed c .

A particle in this structure is characterized by four-spatial-momentum

$$\mathbf{P}_4 = (p_x, p_y, p_z, p_4)$$

where the first three components belong to the directly observable spatial dimensions and p_4 is directed along the fourth spatial dimension. WUC identifies rest energy E as the three-dimensional representation of this fourth component:

$$E = cp_4$$

The central proposition of this paper is:

Energy is our three-dimensional description of the fourth spatial momentum component, transformed by the fundamental expansion speed c .

In this interpretation, four-spatial-momentum is fundamental, while rest energy is an individual-particle property representing its fourth spatial component. The fundamental WUC energy scale

$$E_0 = hc/a$$

corresponds to the fundamental fourth spatial momentum scale h/a . The purpose of the present paper is to develop this physical interpretation of energy and reconsider the question of where energy comes from.

1. Introduction. What Is Energy?

Energy occupies a central position in physics. Physical processes are described in terms of energy transfer, transformation, radiation, and conservation. Energy is used throughout mechanics, electrodynamics, thermodynamics, quantum physics, particle physics, astrophysics, and cosmology.

Yet behind this extraordinary practical success lies a remarkably simple question:

What is energy?

A physical parameter may be precisely defined, calculated, and measured without its deeper physical nature necessarily being identified. Describing how a quantity behaves is not necessarily the same as explaining what that quantity physically represents.

WUC approaches this question through the geometry of the World. The World is considered not as an intrinsically three-dimensional object, but as a three-dimensional Hypersphere forming the surface of an expanding four-dimensional Nucleus.

In this framework, linear momentum possesses four spatial components. The first three are directly observable as three-dimensional momentum. The fourth is directed along the fourth spatial dimension.

The central proposition developed in this paper is that rest energy is the three-dimensional representation of this fourth spatial momentum component.

The purpose of the paper is therefore not to reconsider the many forms, transformations, and applications of energy. It addresses one fundamental question:

What physical quantity do we describe when we speak about the rest energy of a particle?

2. Energy as a Physical Parameter

Physics uses energy as a universal quantitative parameter for describing physical systems and their transformations. Different phenomena are associated with different forms of energy, yet the same physical parameter and units are applicable across them.

This universality raises a conceptual question: **What fundamental physical quantity is represented by energy?**

In the present paper, we distinguish between a physical parameter and the physical entity represented by that parameter.

Energy is measurable, and its changes can be followed quantitatively. These facts, however, do not require energy to be interpreted as an independently existing physical substance.

WUC begins instead with the geometry of the World and asks whether energy can be understood as the three-dimensional representation of a physical quantity that exists naturally in four spatial dimensions.

This approach leads directly to four-spatial-momentum.

3. Four-Spatial Structure of the World

WUC distinguishes between the Eternal Universe and the World. The Eternal Universe exists independently of the finite-age World. The World is a finite, boundless three-dimensional Hypersphere forming the surface of a four-dimensional Nucleus [1,2].

The Nucleus expands in the fourth spatial dimension. Its radius R increases with cosmological time τ according to

$$\frac{dR}{d\tau} = c$$

Thus, c has a fundamental geometrical meaning in WUC: it is the speed of expansion of the four-dimensional Nucleus in the fourth spatial dimension [2].

Physical objects in the World consequently exist within a structure containing four spatial dimensions, although only three are directly observable from within the World. This geometry naturally leads to a four-spatial description of momentum.

4. Four-Spatial-Momentum and the Physical Nature of Energy

In the directly observable three-dimensional World, linear momentum is represented by three components. In WUC, these form part of a more fundamental four-spatial-momentum:

$$\mathbf{P}_4 = (p_x, p_y, p_z, p_4)$$

The first three components lie within the three-dimensional Hypersphere. The fourth component p_4 is directed along the fourth spatial dimension.

The fourth component is no less physical than the other three. It is simply not directly represented as a spatial direction available to an observer confined to the three-dimensional World.

WUC identifies rest energy with the three-dimensional representation of this fourth momentum component:

$$\boxed{E = cp_4}$$

The dimensions of E/c are those of momentum, as required for a fourth spatial momentum component.

The essential point is the physical interpretation. We do not begin with energy and construct a momentum-like coordinate from it. We begin with four-spatial-momentum as a consequence of the four-spatial structure of the World.

The fourth component is fundamental. Energy is its three-dimensional representation.

Therefore:

Energy is our three-dimensional description of the fourth spatial momentum component, transformed by the fundamental expansion speed c .

The appearance of c has a direct physical meaning. In WUC, c is fundamentally the expansion speed of the Nucleus along the same fourth spatial dimension with which p_4 is associated.

Energy is therefore connected directly with the geometry and expansion of the World.

5. Rest Energy as an Individual-Particle Property

In particle physics, rest energy refers to the energy of a particle considered in the frame in which its three-dimensional momentum vanishes [3]:

$$p_x = p_y = p_z = 0$$

In WUC, however, this condition does not imply that the particle's four-spatial-momentum vanishes. The particle retains a nonzero fourth spatial momentum component:

$$\mathbf{P}_4 = (0, 0, 0, p_4)$$

Thus, a particle that is at rest in the three-dimensional World is not at rest in four-spatial terms.

Its fourth spatial momentum component is represented in the three-dimensional description of the World as its rest energy:

$$E = cp_4$$

This provides a direct physical interpretation of rest energy. The three observable momentum components vanish, while the fourth spatial momentum component remains an intrinsic property of the particle.

Rest energy is therefore an individual-particle property corresponding to its fourth spatial momentum component.

Different particles possess different fourth spatial momentum components and consequently different rest energies. Within WUC, this interpretation is particularly important for Universe-Created Particles, which form a discrete multicomponent system characterized by definite rest energies.

6. Fundamental Energy Scale

WUC introduces the fundamental length a and fundamental time t_0 [4]:

$$t_0 = a/c$$

The fundamental rest-energy scale is

$$E_0 = hc/a = h/t_0$$

where h is the Planck constant [4].

Using the four-spatial interpretation of energy, the corresponding fundamental fourth spatial momentum scale is

$$\boxed{p_{4,0} = h/a}$$

Consequently,

$$E_0 = cp_{4,0}$$

For the WUC value

$$a \sim 1.7705641 \times 10^{-14} \text{ m}$$

the fundamental rest-energy scale is approximately

$$E_0 \sim 70.025 \text{ MeV}$$

The significance of these relations is expressed by the sequence:

$$a \rightarrow h/a \rightarrow p_{4,0} \rightarrow cp_{4,0} \rightarrow E_0$$

The fundamental length determines a fundamental momentum scale, while the expansion speed c relates its fourth spatial component to the fundamental rest-energy scale.

This establishes a direct connection among fundamental length, four-spatial momentum, expansion, and rest energy.

7. Universe-Created Particles and Rest Energy

WUC proposes that Universe-Created Matter is continuously generated by the Eternal Universe within the expanding four-dimensional Nucleus through the formation of Universe-Created Particles [5].

Universe-Created Particles possess definite rest energies. In the interpretation developed here, the discrete UCP rest-energy spectrum can therefore also be regarded as a discrete spectrum of fourth spatial momentum components.

The fundamental scale E_0 is particularly significant because it corresponds to the predicted rest energy of DIRAC.

The detailed UCP spectrum and its observational evidence have been considered elsewhere and are beyond the scope of the present paper. Their relevance here is conceptual: rest energy is not merely a numerical label assigned to a particle. It represents a definite component of its four-spatial momentum.

8. Where Does Energy Come From?

The question

Where does energy come from?

can implicitly suggest that energy is a substance that must itself be produced or supplied.

The four-spatial interpretation changes the question.

If energy is the three-dimensional representation of fourth spatial momentum, then the deeper physical quantity is p_4 . Energy does not require an origin independent of the particle whose four-spatial momentum it describes.

For Universe-Created Particles, WUC places their origin in continuous creation by the Eternal Universe within the expanding four-dimensional Nucleus.

The fundamental question therefore becomes:

What is the origin of the four-spatial momentum of particles?

Within WUC, this question is connected with particle creation in the expanding four-dimensional Nucleus.

The rest energy of a created particle is not an additional substance subsequently supplied to it. It is the three-dimensional representation of the fourth spatial momentum that characterizes that particle.

9. Energy Conservation and the Scope of the Present Work

The interpretation proposed here does not alter the empirical principle of energy conservation. Rather, it raises the possibility that this principle may have a deeper interpretation within the framework of four-spatial momentum.

If energy represents the fourth spatial momentum component, conservation of energy may reflect conservation properties of the underlying four-spatial structure. Establishing this connection rigorously, however, requires a theory of particle interactions and four-spatial momentum redistribution.

Such a theory lies beyond the scope of the present paper and will be considered separately.

The present work is deliberately restricted to one fundamental question:

What is energy physically?

10. Discussion

The distinctive WUC claim is not merely the mathematical possibility of writing E/c with the dimensions of momentum. The new element is its physical interpretation.

WUC proposes that the fourth dimension is a real spatial dimension, that the Nucleus physically expands along this dimension with speed c , and that an individual particle possesses a real fourth spatial momentum component. Rest energy is the three-dimensional representation of this component.

The proposal therefore concerns the physical nature of energy rather than merely its mathematical representation.

Several consequences follow from this interpretation. Energy need not be regarded as an independent physical substance. Rest energy becomes a natural individual-particle property. Different particle rest energies correspond to different fourth spatial momentum components.

The fundamental WUC energy scale $E_0 = hc/a$ corresponds to the fundamental fourth spatial momentum scale h/a . Finally, the appearance of c acquires a direct geometrical meaning through the expansion of the Nucleus in the fourth spatial dimension.

The collective angular momentum of particle ensembles, the physical nature of interactions, and the Multiworld structure of different interaction regimes belong to different levels of the WUC framework and are intentionally excluded from the present analysis.

11. Conclusion. The Physical Nature of Energy

Energy is among the most universal physical parameters used to describe Nature. Physics has developed powerful methods for measuring energy, describing its transformations, and applying conservation laws. The present paper addresses a different question:

What does energy physically represent?

World–Universe Cosmology proposes an answer based on the four-spatial structure of the World.

A particle possesses four-spatial-momentum. Three components are manifested as momentum within the directly observable three-dimensional World. The fourth component is directed along the fourth spatial dimension. Its three-dimensional representation is rest energy.

The central conclusion of this paper is therefore:

Energy is our three-dimensional description of the fourth spatial momentum component, transformed by the fundamental expansion speed c .

In this framework, four-spatial-momentum is fundamental. Rest energy is an individual-particle property representing its fourth spatial component.

The fundamental WUC energy scale $E_0 = hc/a$ corresponds to the fundamental fourth spatial momentum scale h/a , establishing a direct connection between the fundamental length, four-spatial momentum, and expansion of the World.

The question **Where does energy come from?** can consequently be replaced by the deeper question:

What is the origin of four-spatial momentum?

Within WUC, this question leads directly to the creation of particles by the Eternal Universe within the expanding four-dimensional Nucleus.

Energy is the three-dimensional manifestation of fourth spatial momentum.

References

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