Real, Existing Dark Matter Candidates

Edward Lulofs
Central Washington University, Ellensburg, WA

December 18, 2018

Abstract

This dark matter candidate has been tested to exist. How well it models current knowledge is to be determined.

1 Introduction

A few years ago, when none of the proposed dark matter hypothetical candidates to explain dark matter had any experimental evidence, the author started thinking about solutions in a different direction. It's possible to return to basics in a number of ways:

1.1) reform the mathematics,

1.2) re-imagine the physical model, or

2) apply a new mathematical approach to a previous physical model.

1.1 A Mathematical Approach

One line of thought is using mathematics to further analyze to current model. No one objects to mathematics when it produces models that agree with laboratory experiments. Modern theories have gotten very math intensive. WIMPS, small black holes, and other ideas are very creative. Laboratory experiments for these models have so far failed. But models that can't be tested are mathematics and not physics. By using previously tested and verified physical theories, this proposed candidate passes this test.

1.2 An Intuitive Approach

A second line of thought is a conceptual, explainable model. This method has been very successful in physics. The first step is to create a mental model of some aspect of the universe. Then a branch of mathematics is applied to that idea of the universe. Predictions are then formed. Physics is falsifiable. When an idea doesn't match experiment, then a different mental model can be created, math applied again, and that concept is tested.

So bring this back to the idea of dark matter. There have been many general relativistic models but Einstein's model has always worked the best. So I am not willing to discard that. Applying this to astronomy, there is mass in the universe that is not being observed.

1.2.1 Known Weakly Interacting Matter

As a point to start from, consider a working physical method: An interesting question is when does matter interact weakly with electromagnetic energy? There are cases when we can't see matter, especially in simple cases. Consider a single hydrogen atom being the only matter in a whole universe.

To conserve conservation of momentum and energy, it is very difficult for radiation to interact with that single atom. The atom is a system in its ground state. There is excitation, ionization, and scattering. Scattering is not available to the dark matter candidate under consideration since no scattering by dark matter has been observed. The only chance we have of interacting is when a photon with energy that matches a transition to an excited state – or ionizes the atom. But there are still problems conserving momentum.

Adding any other matter makes it possible to balance the conservation equations. So widely dispersed hydrogen atoms or molecules between galaxies would be difficult to see. But not impossible, so ordinary luminous matter is not a candidate for dark matter. No one is proposing low density intergalactic hydrogen because there would still be enough interaction to measure some interaction, some scattering, excitation, or ionization with photons.

But the mental model of low interaction of matter in a bound state with radiation seems a promising direction.

1.3 A Short History of Relativistic Quantum Mechanical Theories

Where might this bound state matter be that others have thought about in the past, but have not been included in modern physics theories? The following very short history of relativistic quantum mechanics might be used to find starting points.

1.3.1 Lagrangian

This reminded me of my "basic" RQM, relativistic quantum mechanical, theories. One of the first that was created and for which the author received a Nobel Prize, was a very appealing theory at the time. It used the Lagrangian action and that made it automatically relativistically invariant. Then it predicted new particles and those particles were discovered. This, of course, is Dirac's theory and antimatter.

Where did this antimatter come from? Well, currently we say that we apply a creation operator and the matter and antimatter then exist. Dirac used a mental model. It's called the Dirac sea.

But immediately there were questions that couldn't be answered. For example, how "deep" was this "Dirac sea"? If it was infinitely deep, then there were infinities that could not be dealt with. No one could answer these important questions at the time. Now there is mathematics which answers these questions in very clever ways. [6]

We will come back to the Dirac sea.

1.3.2 QFT has displaced Dirac sea theory: Hamiltonian

Another important start used the Hamiltonian. It is not naturally relativistic, so that problem had to be solved. The solutions became very complicated very quickly. Julian Schwinger found the first theories. Only a few people could solve it and each solution took a long time, on the order of weeks of calculations.

Feynman created the popular and easier to use diagram method for calculations. Then all workers in this field could make much quicker and easier to understand calculations.

A standard model of RQM has been formed by many workers and explains everything in the earthly laboratories.

Then astronomers found a problem that is called "missing mass" and talk of "dark matter" that weakly interacts with photons. Many creative, complex, and original solutions have been proposed, but earthly laboratory experiments have not found these dark matter candidates.

QFT has displaced Dirac sea theory. However, the Dirac sea has been shown to be equivalent to QFT using the Bogoliubov transformation. [1]

Let's try a different approach.

2 Mathematical Foundation for This Approach

An extensive mathematical structure has been constructed leading to "casual fermion systems". [3, 4, 5, 6, 7, 8, 9, 11]

For a less technical introduction see [10]. An even simpler explanation of Dirac sea and casual fermion system is given in the Wikipedia entries Dirac sea and casual fermion system.

2.1 A Test of this Dark Matter Candidate

Using a gamma ray radioisotope source directed at a block of matter will produce electron-positron pairs. QFT says that the photon interacted with matter to conserve momentum and the photon was annihilated and a positron and electron were created. But it has been shown to be equivalent [1] to the photon ejecting an electron from the Dirac sea and leaving a "hole" that we call a positron. This mental model is still used for positive doped semiconductors where the hole acts like a mobile positive charge. This physical model is also used in the BCS theory of superconductivity. This is where the Bogoliubov transformation originally came from. [2]

Staying with the Dirac sea, this might account for some of the missing matter and energy in the universe. Whereas QFT just assumes that there is no matter in the vacuum but still accounts for virtual particles being created and destroyed.

2.2 A Second "Test" of this Dark Matter Candidate with Interesting Consequences

An impractical real experiment, but an interesting thought experiment is to repeat this experiment out between galaxies. If the Dirac sea is contributing to dark matter, the experiment turns out differently. There is now good experimental data that although dark matter fills galaxies and extends beyond their visual ends, dark matter density is lower or even negligible between galaxies. [12] With the same gamma source and matter target, fewer electron-positron pairs would be produced. This would contradict QFT predictions obtained here on Earth.

I expect unified physical theory that included quantum mechanics, general relativity and quantum field theory could account for this.

3 Conclusion

There is no currently accepted reason to exclude the Dirac sea from contributing to dark matter and dark energy.

References

[1] López de Recalde, Andrea (2017). The Standard Electro-Weak Theory, 2nd Edition. Morrisville, North Carolina: LuLu Press, Inc. p. 65. ISBN 978-1-365-65887-7. https://doi.org/10.1007

[2] Bogoljubov, N. N. (March 1958). "On a new method in the theory of superconductivity". Il Nuovo Cimento. 7 (6): 794–805. Bibcode:1958NCim....7..794B. doi:10.1007/bf02745585.

[3] Finster, F. The Principle of the Fermionic Projector, hep-th/0001048, hep-th/0202059, hep- th/0210121, AMS/IP Studies in Advanced Mathematics, vol. 35, American Mathematical Society, Providence, RI, 2006.

[4] Finster, F. Causal variational principles on measure spaces, arXiv:0811.2666 [math-ph], J. Reine Angew. Math. 646 (2010), 141–194.

[5] Finster, F. Entanglement and second quantization in the framework of the fermionic projector, arXiv:0911.0076 [math-ph], J. Phys. A: Math. Theor. 43 (2010), 395302.

[6] Finster, F. A formulation of quantum field theory realizing a sea of interacting Dirac particles, arXiv:0911.2102 [hep-th], Lett. Math. Phys. 97 (2011), no. 2, 165–183.

[7] F. Finster and A. Grotz, A Lorentzian quantum geometry, arXiv:1107.2026 [math-ph], Adv. Theor. Math. Phys. 16 (2012), no. 4, 1197–1290.

[8] F. Finster and N. Kamran, Spinors on singular spaces and the topology of causal fermion systems, arXiv:1403.7885 [math-ph] (2014).

[9] Finster, F. Perturbative quantum field theory in the framework of the fermionic projector, arXiv:1310.4121 [math-ph], J. Math. Phys. 55 (2014), no. 4, 042301.

[10] Causal fermion systems as a candidate for a unified physical theory, arXiv:1502.03587 [math-ph], 2015, Online. https://arxiv.org/abs/1502.03587

[11] Finster, F (2018). Causal Fermion Systems: Discrete Space-Times, Causation and Finite Propagation Speed, preprint.

[12] Nobuhiro Okabe1, Graham P. Smith2, Keiichi Umetsu1, Masahiro Takada3, and Toshifumi Futamase4. LoCuSS: The Mass Density Profile Of Massive Galaxy Clusters At $z = 0.2$ Published 2013 May 17 © 2013. The American Astronomical Society. The Astrophysical Journal Letters, Volume 769, Number 2