# The Cantorian Superfluid Vortex Hypothesis

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The present article suggests a preliminary version of Cantorian superfluid vortex hypothesis as a plausible model of non-linear cosmology. Using the proposed model we explain the physical origin of quantum-like approach to describe planetary orbits as proposed in the recent literature. The meaning of the Cantorian superfluid vortex hypothesis is discussed, particularly in the context of offering a plausible mechanism of gravitation-related phenomena from boson condensation. Some advantages and unsolved questions are discussed.

*Keywords*: superfluid aether, Bose-Einstein condensate, phion, multiple vortices, gravitational instability.

## Introduction

In recent years, there has been a growing interest in the quantum approach to describing orbits of celestial bodies. While this approach has not been widely accepted, the motivating idea of this approach was Bohr-Sommerfeld's hypothesis of quantization of angular momentum, and therefore it shows some resemblance to the Schrödinger wave equation (Chavanis 1999, Nottale 1996, Neto *et al*. 2002). The application of wave mechanics to large-scale structures (Coles 2002) has led to impressive results in terms of prediction of planetary semimajor axes, especially orbits of exoplanets (Nottale *et al*. 1997, 2000). However, a question arises as to how to describe the physical origin of wave mechanics of such large-scale structures. This leads to the Volovik-Winterberg hypothesis of the superfluid phonon-roton as a quantum vacuum aether (Volovik 2001, Winterberg 2002a, 2002b).

To extend the superfluid aether hypothesis further in order to explain nonlinear phenomena in cosmology, we propose a new Cantorian Superfluid Vortex (CSV) hypothesis. The present article discusses some questions related to this hypothesis, including:

a. What is the meaning of Cantorian Superfluid Vortex?
b. Why do we require this model?
c. How can we represent various high-temperature phenomena in cosmology using low-temperature superfluid physics?
d. What are its advantages and implications compared to present theories?
e. What are the unsolved questions and possible future research?

We begin with question b, in particular with reference to reconciling Quantum Mechanics and GTR. Further discussion of the proposed hypothesis will be reserved for a forthcoming article.

## QM, GTR, QED, Sachs

For almost eight decades theoretical physicists have toiled to reconcile Quantum Mechanics and Einstein's (General) Theory of Relativity, beginning with Dirac, and continuing with leading scientists up to this time. As a result, several different approaches are taken by theoretical physicists today, including such theories as:

- QED & QFT: these can be considered as two of the best experimentally confirmed theories up to this day. For an introduction, see for example Weinberg (1993, 1997) and Siegel (1999).

- Sachs's theory: in principle Sachs has attempted to bring the four-dimensional geometrical world into QM.[1]
- Other refinements of GTR such as Weyl's (conformal gravity) solution, *etc*.
- Various versions of string theories: supergravity, superstring, supersymmetry, brane universe, *etc*.
- One lesser known approach is the diametrical opposite of Sachs's approach: it claims that quantum (wave) mechanics theory is sufficient to explain the phenomena corresponding to GTR (Coles 2002).

A major obstacle here is how to reconcile the four-dimensional geometrisation of GTR with common three-dimensional QM. As is well known, GTR was constructed as a geometrification of physical reality: GTR's attempt to describe gravity is purely geometric and macroscopic. As such, there are some known limitations in GTR,[2] including:

a. Classical general relativity by itself is unable to predict the sign of the gravitational force (attraction rather than repulsion). Consoli (2000) also noted: "*Einstein had to start from the peculiar properties of Newtonian gravity to get the basic idea of transforming the classical effects of this type of interaction into a metric structure.*" In other words, it seems that GTR is not the *complete* theory Einstein was looking for.
b. There is no mechanism for gravitational forces: the 'graviton' has never been observed.

c. There is no convincing mechanism to describe the interaction between matter, inertia, and space (Mach principle is merely postulated).
d. There is no description of the medium of space. Although Einstein apparently considered a perfect fluid to describe this medium in his Leiden lecture in 1921 (Einstein 1921), he never attempted to theorize this medium formally—perhaps for good reason.[3]
e. It is quite difficult to imagine how matter can affect the spacetime curvature and *vice versa* as postulated by GTR (for instance H. Arp).
f. Using GTR it is also quite difficult to explain the so-called 'hidden matter' which is supposed to exist in order to get average density of matter in the universe that required for flat universe, $\Omega$=1 (Chapline 1998). Alternatively some theorists have shown we can reconcile this issue using Navier-Stokes model (Gibson 1999).
g. The spacetime curvature hypothesis cannot explain phenomena in the micro world of Quantum Mechanics. In contrast, by the Ehrenfest theorem, Quantum Mechanics reduces to classical physics if we use classical parameters consistently (see also Signell 2002).

However, we should recognize that the strong point of GTR is to generalize the Maxwell equations to the gravity field and to introduce the equivalence principle, as observed by recent experiments. Therefore according to Consoli (2000): "all classical experimental tests of general relativity would be fulfilled in any theory incorporating the Equivalence Principle." We should also note that Einstein was quite right in pointing out the incompleteness of QM (as described by the Copenhagen school). Therefore, we would expect to find a reformulation of QM, which is capable of describing known phenomena in support of GTR, such as the bending of light rays, clock delay due to the gravitational field and also the precession of the perihelion of planet Mercury. Attempts to generalise (QM) wave mechanics to describe the motion and distribution of celestial objects have been made, for instance by Coles (2002), Neto *et al*. (2002), Nottale *et al*. (1997, 2000) and Zakir (1999).

Therefore, we may conclude the following: to reconcile GTR (phenomena) and QM, we have to begin by finding the mechanism of gravitation and its interaction with the medium of space. This leads us to the scalar field hypothesis as discussed below.

## Whittaker, scalar field, phion condensate

The scalar field hypothesis as a description of gravitation is not a recent idea at all. Whittaker, a leading physicist and mathematician in his time, originated the idea of a (longitudinal) scalar field while studying the nature of partial differential equations.[4] To quote Whittaker:

> *…the gravitational force in each constituent field will be perpendicular to the wave-front: the waves will be longitudinal… this undulatory theory of gravity would require gravity should be propagated with a finite velocity, which however need not be the same as of light, and may be enormously greater.*

Whittaker's student, Dirac, upon reading Whittaker's idea, then came up with his idea of the 'electron sea', though this was later found to be at odds with observation. Therefore the scalar field must be closely linked to the medium of space (aether, or its modern version '*quantum vacuum fluctuation';* see Chapline 1998, Rothwarf 1998). In Whittaker's formulation, one of the features of this scalar field is that its speed is much higher than the speed of light *c*. This hypothesis is recently supported by Van Flandern's theory on the 'speed of gravity'.[5]

Now if we accept that a scalar field can describe the mechanism of gravitation, the question then arises: *what is the physical nature of this scalar field.* Some physicists have argued that gravitation is actually a long-wavelength excitation of a scalar condensate inducing spontaneous symmetry breaking (Consoli 2000, 2002). This scalar field is represented by the 'phion condensate'. In this sense, the Mach principle represents an inextricable linkage between inertia and gravity due to the common origin of the phenomena: condensation of the scalar field.[6]

We now come to the core hypothesis of CSV theory: *the 'phion condensate' can be modeled by zero temperature superfluid physics* (Consoli 2000). Therefore, we treat the 'superfluid' as the quantum vacuum aether medium (as proposed by Winterberg 2002a, 2002b). In this way, we are no longer considering superfluidity merely as a useful analogy to describe various phenomena of cosmology (Volovik 2000b, 2001), but instead as a *real* fluid medium in accordance with Gibson's model (Gibson 1999).[7] In this regard, it becomes very convenient to consider the Navier-Stokes equations (Zalaletdinov 2002). Furthermore to represent a real superfluid model in cosmology, we propose a new term: 'superfluid cosmology.' This conjecture implies that there should be various nonlinear phenomena in cosmology which are thus far inexplicable using the 'geometrification' approach, including the 'hidden matter' problem. In other words, if we use a real fluid model for nonlinear cosmology, we do not have to invoke some kind of exotic matter to explain the nature of 'hidden matter'.

Now, with regard to GTR experiments, we also consider Consoli's (2000) idea that "all classical experimental tests of general relativity would be fulfilled in any theory incorporating the Equivalence Principle." Therefore, because the CSV hypothesis was in principle also based on the same phion condensate mechanism, we can predict the same effects as were predicted by Consoli (2000).

Furthermore, the real Cantorian superfluid model also implies that it is possible to conduct a set of laboratory experiments to replicate real cosmological objects (Volovik 2001, Zurek 1995), provided we take into consideration proper scale modeling (similitude) theories.

## What is the Cantorian superfluid vortex?

Once we agree with the above proposition on the role of phion condensate in describing the gravitational interaction, we are now ready to consider the meaning of the Cantorian Superfluid Vortex (CSV) hypothesis. Term 'Cantorian'[8] here represents the *transfinite set* introduced by Georg Cantor. As we know, the transfinite set introduces the mapping of a set onto itself, better known as a 'self-similar' pattern. This pattern is observed in various natural phenomena, including vortex phenomena. The notion of Cantorian vortices can be defined in simple terms as the tendency of multiple vortices to be present in a real fluid medium, including superfluidity. (See Nozieres & Pines 1990, Quist 2002, Volovik 2000a, 2000b, 2000c.)[9] Therefore, with regards to superfluid cosmology, in principle the Cantorian Superfluid Vortex hypothesis suggests that there is a tendency in nature as follows:

### Lemma I: "There are mini vortices within bigger vortices *ad infinitum*."

A flow pattern where the streamlines are concentric circles is known as a circular vortex. If the fluid particles rotate around the vortex centre, the vortex is called rotational. It also follows that the vortex moves with the fluid. It is also known that real fluid flow is never irrotational, though the mean pattern of turbulent flow outside the boundary layer resembles the pattern of irrotational flow. In rotational flow of real fluids, vorticity can develop as an effect of viscosity. The term 'vorticity' is defined as the number of circulations in a certain area, and it equals the circulation around an elemental surface divided by the area of the surface (assuming the vortex lattice exists). Since the vortex moves with the fluid, the vortex tube retains the same fluid elements. and these elements retain their vorticity. And provided other factors remain the same, vortices can neither be created nor destroyed in a non-viscous fluid.

In quantum fluid systems like superfluidity, it is known that such vortices are subject to a quantization condition of integer multiples of 2π, or $\oint v_s.dl = 2p.n\hbar / m_4 = n.k_o$. Such quantized vortices are distributed at equal distance from one another, which is known as vorticity. Furthermore, in large superfluid systems usually we use Landau two-fluid model, with normal and superfluid components. The normal fluid component always possesses some nonvanishing amount of viscosity and mutual friction.

This vortex formation phenomenon is well known in various turbulence-related fluid phenomena such as tornadoes and tropical hurricanes; and it can be represented by the Navier-Stokes equation (Zalaletdinov 2002). Therefore, mathematically we treat the 'vortex' as a stable solution (Kivshar *et al*. 1999) and a consequence of Navier-Stokes equation. Furthermore it is known there is *exact mapping* between the Schrödinger equation and Navier-Stokes equation (Kiehn 1989, 1999), therefore the Cantorian Superfluid Vortex hypothesis requires a second conjecture:

### Lemma II: "Vortices are considered stable solutions of the Navier-Stokes equations."

Since we know the Navier-Stokes equation leads us to nonlinear fluid phenomena in cosmology (Gibson 1999) and also superfluid vortices (Godfrey *et al*. 2001, Prix 2000), then the Cantorian Superfluid Vortex hypothesis also proposes:

### Lemma III: "Cantorian Superfluid Vortex theory is capable to represent various phenomena of nonlinear cosmology."

Nottale's Scale Relativity Theory (Nottale 1996, 1997, 2001, 2002) leads us to some interesting implications including:

I. The Euler-Newton equation can be generalized to represent various phenomena in cosmology across different scales. Because the Euler-Newton equation can be considered a subset (in the inviscid limit) of the Navier-Stokes equation, then the Navier-Stokes equation can also be considered applicable to any scale (scale covariant).

II. Because Scale Relativity Theory can be used to derive the Dirac equation (Celerier & Nottale 2002), we also conclude that Scale Relativity Theory implies there is an 'electron sea' medium, in Dirac's words, to represent interactions across different scales.

Hence we may also conclude that:

**Lemma IV: "The Cantorian Superfluid Vortex is a plausible medium to describe the motion of various celestial objects governed by the Navier-Stokes equation, and to represent a medium for interactions across various scales."**

In other words, and considering the *exact correspondence* between the Schrödinger equation and the Navier-Stokes equation, the Cantorian Superfluid Vortex hypothesis also suggests:[10]

**Lemma V: "Schrödinger equation can be treated as a real diffusion theory, capable of describing various celestial phenomena at various scales."**

In this sense, despite some similarities in their consequences and cosmological implications, the Cantorian Superfluid Vortex model is quite different from Nottale's Scale Relativity Theory, since it relies on a real fluid model right from the beginning.[11] Using this model, we can expect to get a proper mechanism and medium for gravity interactions, which GTR is lacking.

A question arises here concerning whether the proposed Cantorian Superfluid Vortex hypothesis is really *different* from Nottale's Scale Relativity Theory. Therefore it is perhaps worth mentioning here Nottale's own opinion (Nottale 1996):

> *We stress once again the fact, diffusion here is only an* interpretation*. Our theory is not statistical in its essence, contrarily to quantum mechanics or to diffusion approaches. In scale relativity, the fractal space-time can be completely 'determined', while the undeterminism of trajectories is not set as a founding stone of the theory, but as a consequence of the* nondifferentiability *of space-time. In our theory, 'God does not play dice', …*

> *In summary, our point of view is quantum objects are neither 'waves' nor 'particles', ... while our experiments, being incomplete, put into evidence only the module. There is no* 'complementarity' *here, since the phase is never directly seen,…. There is therefore no mystery when one can jump instantaneously from observing the 'wave' behavior to observing the 'particle' behavior without physically disturbing the system, but only by changing the observing way. Both properties were present before the observation, even if only one of them was seen.*

In other words, we argue here that Nottale's Scale Relativity Theory is insightful in its representation of a scale covariant theory of gravitation, but it is lacking an explanation of the medium of the gravitation interaction mostly due to th evagueness of the distinction between the real diffusion theory and the statistical interpretation of QM (in particular, Schrödinger equation).[12]

Furthermore, this could have been anticipated, because Nottale's Scale Relativity Theory tends to neglect the significance of real medium modeling: it has some inherent limitations in predicting nonlinear phenomena in cosmology (Gibson 1999).

In this regard, the Cantorian Superfluid Vortex hypothesis can be considered an extended version of Nottale's scale relativity theory toward a real fluid model of nonlinear cosmology. In other words, the proposed Cantorian Superfluid Vortex theory considers Scale Relativity Theory merely a transformation theory, such as STR or the Ehrenfest theorem: its contribution is to show the generality and applicability of the Schrödinger equation for predicting phenomena at cosmological scales. However, in the present author's opinion, Nottale's Scale Relativity Theory lacks a convincing description of why and what kind of medium and mechanism can represent these phenomena.

## What are its advantages over the present theories

From the Cantorian Superfluid Vortex hypothesis we can expect certain advantages over existing theories, including:

a. Describes the origin of outer planet distribution in a (planar) solar system, without invoking an *ad hoc* second quantum number as Nottale (1996) or Neto *et al.* (2002) did;
b. Predicts the existence of a vortex center in galaxies (similar to the 'eye' in hurricane and tornadoes);
c. Predicts new planets in the outer orbits beyond Pluto;
d. Explains the same phenomena as predicted by GTR (precession of perihelion of Planet Mercury, *etc*.) similar to what has been suggested by Consoli (2000);
e. Describes the physical nature of the quantum vacuum aether medium and also the mechanism of the gravitation interaction (Chapline 1998, Consoli 2000, 2002);
f. Simplicity preserved by retaining the notion of three dimensional space and one dimension time; thus QM can be generalized to cosmological scales naturally (Coles 2002, Neto *et al*. 2002, Signell 2002, Zakir 1999, Zurek 1995);
g. Explains why the universe is observed as flat Euclidean, not as curved spacetime as predicted by Einstein (flat spacetime has also been considered for instance by K. Akama and P.V. Moniz).[13] This is because *there is no such thing as curved spacetime*, at least not in the proposed Cantorian Superfluid Vortex theory (see also Chapline 1998, Winterberg 2002a, 2002b);

h. Solves some known paradoxes in QM.

## Unsolved questions and possible future research

Despite the above advantages, there are unsolved questions that require further research, including:

- Explain other nonlinear cosmological phenomena from superfluidity viewpoint, including nebulae, pulsars, neutron stars, gamma ray bursts, *etc*. (DeAquino 2002, 2002a, Gibson 1999, Sedrakian & Cordes 1997);
- Reconcile the proposed Cantorian Superfluid Vortex theory with various phenomena at quantum scale, as predicted by QED, *etc*. (Nottale 1996, 1997, 2001, 2002a, 2002b);
- Provide a mathematical explanation of various known QM paradoxes;
- Explain known electromagnetic theories of Maxwell, *etc*.;
- Provide a measurable prediction of the smallest entity in nature. The proposed Cantorian Superfluid Vortex theory prefers 'vorton' instead of 'photon' as the smallest entity in nature.

Other phenomena may have been overlooked here. The above list is merely an introductory '*to-do list'*.

In the present article we have discussed some reasons for considering Cantorian superfluid vortices as the basis of cosmology modeling. While of course this approach has not been widely accepted yet, in the author's opinion it could reconcile some known paradoxes both in quantum mechanics (*e.g*., duality of wave-particle), and also in cosmology (clustering, inhomogeneity, hidden matter). Further discussion of the proposed hypothesis will be reserved for a forthcoming article where some implications and open questions will be discussed. Furthermore, in the near future we expect that there will be other theories based on a real fluid model, which are capable of predicting various cosmological phenomena in a more precise way.

## References


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## Notes

[1] See the articles by Mendel Sachs at http://www.compukol.com/mendel, also *Annales Foundation Louis de Broglie* vol. 27, 85 (2002). Also Chapter 11 in

*Modern Nonlinear Optics* Part I. Advances in Chemical Physics, Volume 119, Series editors: I. Prigogine *et al.,* John Wiley & Sons, Inc. (2002).

[2] For more discussion on this issue, we refer to C. Will's report: '*The confrontation between general relativity and experiments: 1998 update,*' McDonnell Center for the Space Sciences, Washington University. Recently there are also some articles discussing some features indicating incompleteness of GTR, for example *arXiv:gr-qc/0102056*, particularly related to the so-called Pioneer anomaly.

[3] See Munera (1998), who provides calculation to show Michelson-Morley experiments actually never were null. Since Michelson-Morley experiments are often considered as the building block of relativity theory (STR), we know what this article suggests.

[4] See Whittaker, E., *On the partial differential equations in mathematical physics*, Cambridge Univ., (1903).

[5] See articles by T. Van Flandern at http://www.metaresearch.org

[6] Of course, there are several other interpretations of the nature of the scalar field besides the 'phion condensate.' See for instance Barcelo *et al.* (2000), Dereli & Tucker (2000), Roberts (2001), Siegel (2002).

[7] See also other articles by Gibson at *arXiv.org:astro-ph/9904230, 9904237, 9904260, 9904284, 9904283, 9904317, 0003147, 9911264, 9904362, 9904269, 9904366, 9908335, 0002381.*

[8] Recently Castro, Granik, & El Naschie (2000) reintroduced this term to describe the exact dimension of our universe.

[9] There is already literature describing vortices in some cosmology phenomena, for instance Barge & Sommeria (1995) and also Chavanis (1999).

[10] In this regards, see Coles (2002), Neto *et al*. (2002), Rosu (1994), Zakir (1999).

[11] For a discussion on the meaning of interpreting Schrödinger equation as real fluid phenomena, see also Rosu (1994).

[12] See also Neto *et al*. (2002), Rosu (1994), Zakir (1999).

[13] See for instance P.V. Moniz (*arXiv:gr-qc/0011098*) and K. Akama (*arXiv:hep-th/0007001, hep-th/0001113*).