IRREDUCIBLE INVISCID SINGULAR REPRESENATION OF 3D FULLY DEVELOPED TURBULENCE AND RELATED EMERGENT PHYSICS

M.I. AKSMAN
MAKSMAN123@GMAIL.COM

Abstract

- Vortons introduced to approximate finite core vortex tubes and pass through Navier Stocks spontaneous singularities/reconnections without any additional assumptions.
- Vortons provide irreducible description of inviscid attractor of 3D Navier Stocks equation solutions with number of vortons scaling with Reynolds number at hand.
- Magnetic vortons provide irreducible description of magnetic vortex tubes in plasma with reconnections without any additional assumptions.
- Instability of quasi 3D/2D+ vorton collapse provides possible mechanism for explosive universe inflation/first order phase transition.
- 3D space nature of our universe as a consequence of instability of 3D vortons collapse.
- "Dark matter" explained as a consequence of frisbee like quasi 3D/2D+ space in galaxies with corresponding stable rotational curves.
- "Dark energy" explained as a emergent result of vortons system 3D self amplification interactions energy "antigravity" effect.
- Probabilistic interpretation of quantum mechanics as a result of smooth test functions of fluid vacuum nonlinear Maxwell equations weak solutions.
- Baryonic asymmetry explained as a instantaneous snapshot during exponential inflation of quark antiquark annihilation asymmetry/skewness and kurtosis terms in Edgeworth series expansion of instantaneous quantum GUP (generalized uncertainty principle) fluctuations.
- Simple Early Bifurcation/Regime shift detection in nonequilibrium nonlinear statistical systems proposed using linear statistical moments/cumulants approximation/equivalents formulas.

Key Words: Vortons, solenoid dipole singularities, 3D turbulence, vortex reconnections, inviscid dissipation, Navier Stokes attractor, instability of 3D vorton collapse, universe inflation, dark matter, dark energy, 3D physical space, emergent antigravity, probabilistic interpretation of quantum mechanics, nonlinear Maxwell equations, baryonic asymmetry, Edgeworth series expansion, GUP generalized uncertainty principle, hemispherical power anomaly, statistical moments, skewness.

SECTION 1: Introduction.
Navier-Stokes solutions and vorton dynamics.

The 3D Euler equations of incompressible inviscid fluid develop spontaneous singularities on timescales on the order of vortex rotations. Solutions to the 3D Navier-Stokes equations for incompressible viscous flow are smooth for all time, but they bifurcate and are not unique Ref.[6-8,29].

Vorton is the simplest solenoid 3D vortex singularity Refs.[1-5,29]. Finite core vortex tubes may be represented as superposition of vortons Refs.[1- 5]. Experimentally observed topological metamorphoses of vortex structures/reconnections could be seen in numerical vorton simulations without any additional assumptions. Vortons in plasma have magnetic dipole moments. Magnetic vorton tubes reconnect Refs.[3-5,14,29].
The 3D Navier-Stokes equations appear to have spontaneous singularities/reconnections and an inviscid vorton attractor that exhibits inviscid turbulence and dissipation Refs.[1- 5, 10,29] with corresponding Kolmogorov like energy cascade towards small scale.
Original reasons for introduction of vortons were to resolve the most important structures for description of fully developed 3D turbulence, 3D vortex finite core tubes/filaments Ref.(1-5,29), Eq.(1-5) and ability to pass through spontaneous singularities of Navier Stokes equations, which turn out to be bifurcations/branching of solutions/reconnections of vortex filaments/tubes.

Vorton is solenoid dipole 3D vorticity singularity. Velocity field generated by individual vorton.

$$\upsilon_i^{(\alpha)}(t,x) = -\frac{\epsilon_{ijk}\left(x_j - x_j^{(\alpha)}\right)\gamma_k^{(\alpha)}}{4\pi\left|x - x^{(\alpha)}\right|^3} \ , \qquad (1)$$

where ϵ_{ijk} is the unit antisymmetric tensor, and $x_j^{(\alpha)}$ (t) and $\gamma_k^{(\alpha)}$ (t) are the components of position and intensity, respectively, of the vorton labeled α.

Vorticity field of individual vorton. See solenoid dipole field picture fig.(19).

$$\Omega_i^{(\alpha)}(t,x) = \gamma_i^{(\alpha)}\delta\left(r^{(\alpha)}\right) + (4\pi)^{-1}\left(3r_i^{(\alpha)}r_k^{(\alpha)}\gamma_k^{(\alpha)} - \left|r^{(\alpha)}\right|^2\gamma_i^{(\alpha)}\right)\left|r^{(\alpha)}\right|^{-5} \qquad (2)$$

Where $\delta\left(r^{(\alpha)}\right)$ is a δ-function.

Which obviously is non local field.

Vorton intensity change due to interaction with other vortons.

$$\dot{\gamma}_i^{(\alpha)} = \frac{\epsilon_{ijk}}{4\pi}\sum_\beta\left(r_{\alpha\beta}^{-3}\gamma_j^{(\alpha)} - 3r_{\alpha\beta}^{-5}r_j^{(\alpha\beta)}r_m^{(\alpha,\beta)}\gamma_m^{(\alpha)}\right)\gamma_k^{(\beta)}, \qquad (3)$$

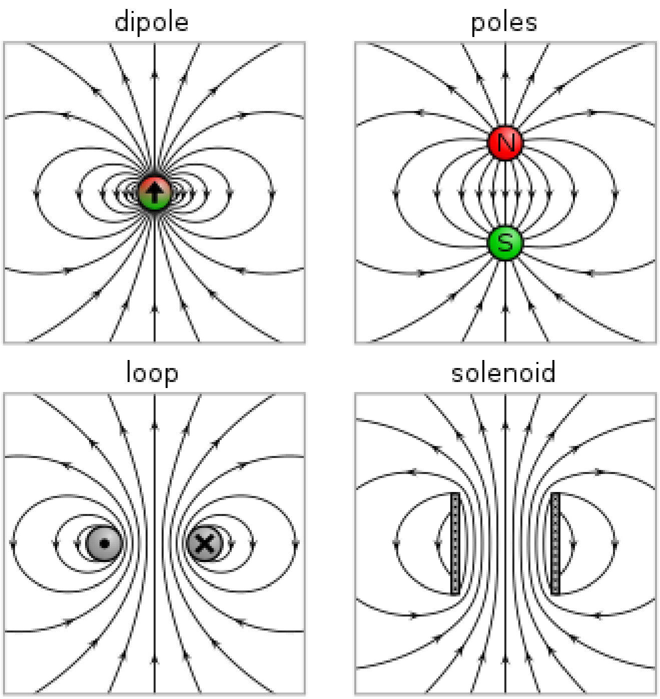
$$\mathbf{r}_i^{(\alpha,\beta)} \equiv \mathbf{x}_i^{(\alpha)} - \mathbf{x}_i^{(\beta)}, \mathbf{r}_{\alpha\beta} \equiv \left|\mathbf{r}^{(\alpha,\beta)}\right|.$$

Vorton position change due to interaction with other vortons.

$$\dot{\mathbf{x}}_{\mathbf{i}}^{(\alpha)} = -\frac{1}{4\pi}\epsilon_{\mathbf{ijk}}\sum_{\beta=1}^{N}{}' \, \mathbf{r}_{\alpha\beta}^{-1}\,\mathbf{n}_{\mathbf{j}}^{(\alpha,\beta)}\gamma_{\mathbf{k}}^{(\beta)}, \qquad \textbf{(4)}$$

$$\mathbf{r}_{\mathbf{i}}^{(\alpha,\beta)} = \mathbf{x}_{\mathbf{i}}^{(\alpha)} - \mathbf{x}_{\mathbf{i}}^{(\beta)},$$
$$\mathbf{r}_{\alpha\beta} = \left|\mathbf{r}^{(\alpha,\beta)}\right|,$$
$$\mathbf{n}_{\mathbf{i}}^{(\alpha,\beta)} = \mathbf{r}_{\mathbf{i}}^{(\alpha,\beta)}\mathbf{r}_{\alpha\beta}^{-1}$$

Fig.(1,2,19).



Vorton's vorticity field, solenoid dipole. Vorticity and magnetic dipole fields Ref.(1-5,14).
Fig. 19.

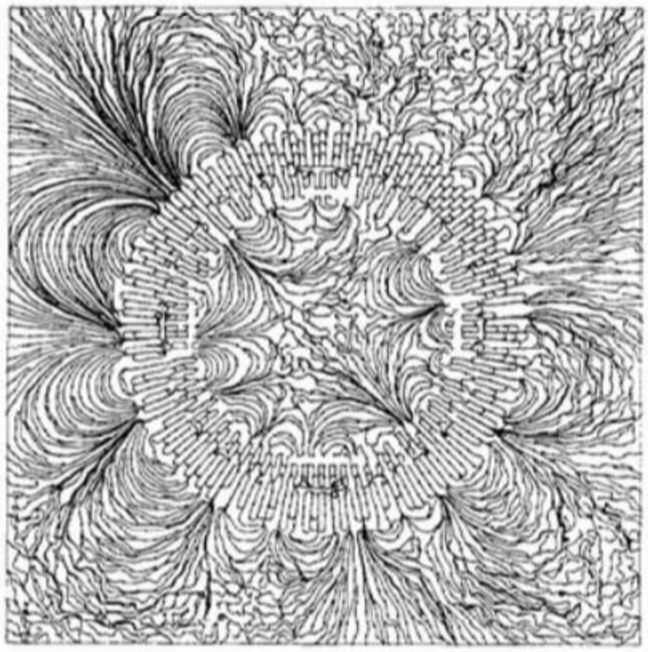


Fig. 1. Distribution of vorticity (vortex lines) in the plane of 80-vorton ring.

Vortex tube clearly seen in a vorton ring. With vortons vorticity cancelling out beyond it Refs.(3-5).

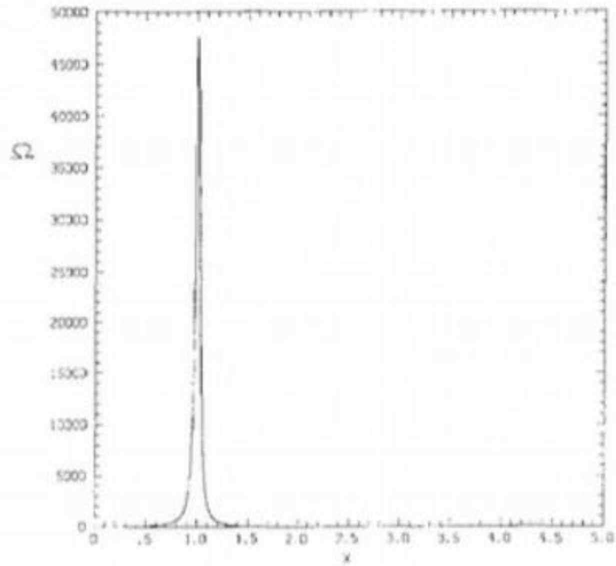


Fig. 2. Cross section of vorticity distribution in 80-vorton ring.

Non zero vorticity around radius of the ring ref.(3-5).

In fact we showed both analytically and numerically that chain of vortons approximates finite core vortex tubes with number of vortons corresponding to Reynolds number at hand Refs.(1-5), Fig.(1,2,19).
Another hope was that by introducing simplest solenoid vortex singularities which are analytically tractable we would be able to pass through some unknown NS "singular events" without any additional assumptions. Those events turn out to be vortex reconnections corresponding to bifurcations and branching of 3D NS solutions Ref.(1-5,29), Fig.(3-18). Both reasons appear to work out despite later vorton critiques, "modifications" and "improvements" Refs.(21-23).
Thus bifurcation and branching of Navier-Stokes solutions Refs.[6-9] can be interpreted as inviscid vorton reconnections Ref.(3-5). Very likely vortons describe dynamics on the Navier-Stokes attractor Ref.[9]. From a physical point of view vortons resolve the entire 3D vorticity field, which is superposition of 3D vortex tubes and is the only important aspect for 3D fully developed turbulence dynamics representation. And vortons showed ability to pass through NS "singular events" without any additional assumptions based on vortons inviscid dissipation ability Ref.(3-5,29).
We know from analysis Ref.[10] that the limit of a smooth sequence of functions may not be smooth. So even if Navier-Stokes solutions are all smooth, their inviscid limit could be singular. These singular inviscid solutions express the bifurcation of viscous solutions and finite dissipation rates. Rudin's math analysis book Ref.[10] says that limit of smooth sequence could be singular. So even if 3D NS solutions are smooth their limit/attractor could be singular/inviscid, especially if it explains all NS solutions dynamics without any additional assumptions and provide most economical/irreducible description of dynamics of 3D NS solutions for fully developed turbulence.

SECTION 2: Vortex singularities and inviscid energy dissipation

Singular vortex dipoles, i.e. vortons, interact according to formulas Eq.(3,4),Ref.[1- 5]. As a consequence their amplitudes may self-amplify, a reflection of vortex stretching in three dimensions.

The interaction energy of vortons is given by Eq.(6),Ref.[1-5].

$$\mathcal{E}_{\rm int} = \frac{1}{8\pi}\sum_{\alpha<\beta} \mathrm{r}_{\alpha\beta}^{-1}\left(\gamma_i^{(\alpha)}\gamma_i^{(\beta)} + \gamma_i^{(\alpha)} n_i^{(\alpha,\beta)}\gamma_j^{(\beta)} n_j^{(\alpha,\beta)}\right) \qquad (6)$$

Interaction energy of vortons Refs.(2-5).

The self-energy of a single vorton is infinite, therefore it is not included in that formula. Due to the three dimensional stretching of vortons and self amplification, the interaction energy is not conserved. We may imagine that it goes into or comes out of the infinite self-energy of individual vortons Ref.[1- 5].
In the real world this corresponds to the fact that internal rotational degrees of freedom of 3D vortices are not resolved in the interaction energy formula. The stretching energy of vortex interactions may go into or out of unresolved rotational motions. Physically energy is

dissipated at small scales by viscosity, but the precise amount is determined by inviscid dynamics.
The same phenomenon occurs in shock waves in compressible fluids, and also in magnetic field reconnection in the solar atmosphere. Dissipation provides the mechanism, but inviscid dynamics governs the behavior while viscosity, diffusivity, and resistivity play mop-up roles Ref.[16-18].
We performed numerical experiments with two vorton rings executing a "leapfrogging" cycle. The rings always self-destructed after 5 periods, regardless of the number of vortons in the rings.
Multiple reconnections then happened, with small rings appearing. During the destruction of the original rings we observed a negative spike in the vorton interaction energy, and a Kolmogorov-like energy power spectrum developed. This agrees with the physical phenomena of energy transfer to small scales and inviscid dissipation of vorton interaction energy Eq.(5),

(5)

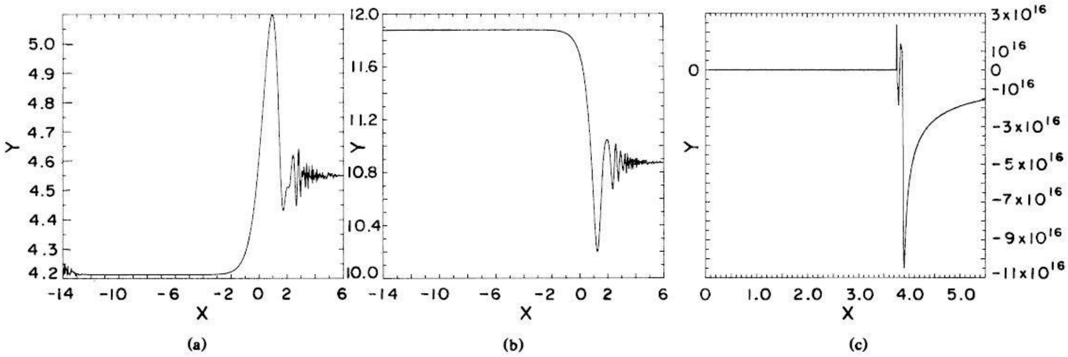
$$\mathbf{E_{int}(k) = \frac{1}{2\pi^2}\sum_{\alpha,\beta}\left[\phi_1(kr_{\alpha\beta})\gamma_i^{(\alpha)}\gamma_i^{(\beta)} + \phi_2(kr_{\alpha\beta})\gamma_i^{(\alpha)}n_i^{(\alpha,\beta)}\gamma_j^{(\beta)}n_j^{(\alpha,\beta)}\right]},$$

(6)

$$\mathbf{\phi_1(z) = z^{-3}[(z^2-1)\sin z + z\cos z],\ \ \phi_2(z) = z^{-3}[(3-z^2)\sin z - 3z\cos z]}$$

Vortons interaction energy as a function of wave number Refs.(2-6).

Fig.(20).



Energy spectrum of two leapfrogging vortex rings originally and at the moment of self distraction. Slope in log-log graph around -1.7. Plus negative spike in time derivative of interaction energy during distraction of the rings Ref.(2,3,5,29).

Recent experiments on colliding vortex rings show strikingly similar behavior, with large numbers of vortex reconnections and the appearance of multiple small rings Refs.[19].

SECTION 3: 3D Navier-Stokes attractor dimension

Again, in simple terms 3D NS attractor is a minimal/irreducible set, number of equations that describe dynamics of 3D Navier Stokes solutions without any additional assumptions.
A chain of vortons can approximate a vortex tube with a finite core size that is roughly equal to the distance between vortons Ref.[1-5,29], see Fig.(5) for a ring with 80 vortons. This observation allows us to estimate the dimension of the attractor of the 3D Navier-Stokes equations in fully-developed turbulence.
We start by assuming that the vorticity consists of one-dimensional tubes whose core size is the Kolmogorov microscale **Re^-3/4** Ref.[1-5,13] and is a distance between neighbour vortons in a tube. Therefore the number of vortons needed to resolve such tubes is on the order of **Re^3/4**. We deduce that the dimension of the Navier-Stokes attractor is **Re^3/4**, which is the cube root of the usual Kolmogorov estimate of **Re^9/4** Ref.[1-5,13] based on resolving the 3D velocity field with the same accuracy.

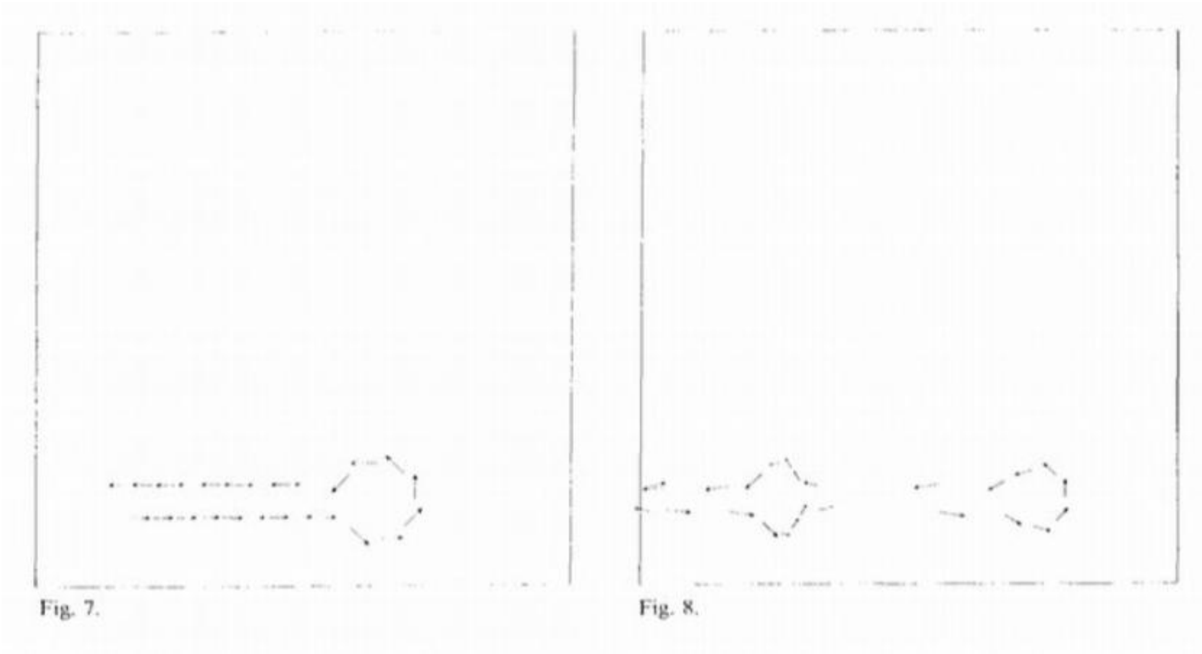
SECTION 4: Magnetic vortons

The vorticity field of a vorton is identical in structure to the magnetic field of a magnetic dipole Fig.(19). In fact, in a turbulent plasma every vorton becomes magnetic due to the rotation of electrically charged plasma. So magnetic vortons interact both as a vorticity and magnetic dipoles Eq.(3,4,7).
Formula for force F between 2 magnetic dipoles **m1** and **m2** Ref.(14).

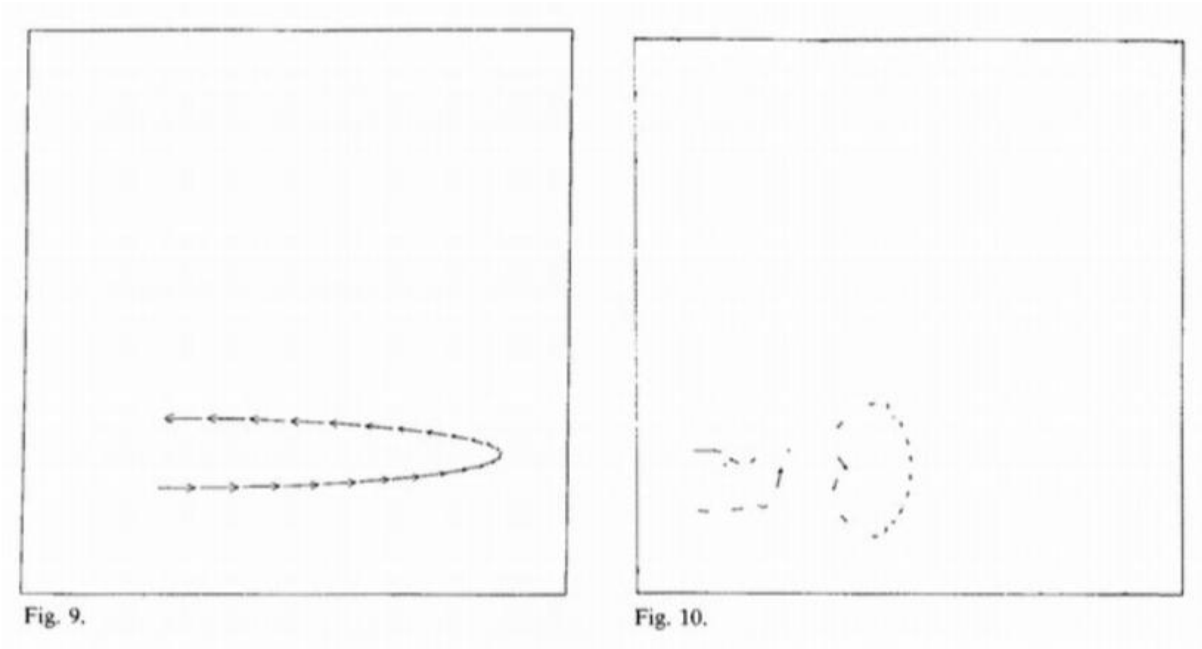
(7)

$$F = \frac{3\mu_0}{4\pi|r|^4}\{(\hat{r}\times m_1)\times m_2 + (\hat{r}\times m_2)\times m_1 - 2\hat{r}(m_1\cdot m_2) + 5\hat{r}[(\hat{r}\times m_1)\cdot(\hat{r}\times m_2)]\},$$

where $\boldsymbol{\mu_0}$ is the magnetic constant**,** $\boldsymbol{\hat{r}}$ is a unit vector parallel to the line joining the centers of the two dipoles, and |r| is the distance between the centers of $\mathbf{m_1}$ and $\mathbf{m_2}$.
Also, the magnetic amplitude and the vorticity amplitude will remain in a constant ratio, as they are stretched by the same fluid strain field. Formulas Eq.(3,4,7) describe the evolution of the magnetic vorton amplitude and their dipole-dipole interaction; note that there is no self-amplification of magnetic dipole momentum through magnetic interactions since the Maxwell equations are linear Ref.[14].
In section (3) we saw that chains of vortons provide an approximation of finite-core vortex tubes. Similarly, chains of magnetic dipoles provide an approximation of finite core magnetic flux tubes, as may be observed in the Sun or in nuclear fusion experiments. Inviscid dissipation associated with reconnection of magnetic vorton tubes may be the energy source for the very high temperatures on the surface of the Sun.
Our vorton horseshoe numerical experiments show reconnection and the expulsion of vortex rings, see Figs. [1,4,5].



Perturbed horseshoe vortex and it expelling vortex ring ref.(3-5).



Unperturbed horseshoe vortex and it expelling vortex ring Refs.(3-5,29).

These resemble the magnetic vortices that produce magnetic storms on Earth and disrupts magnetic confinement in plasma fusion experiments Ref.[16,17].

SECTION 5: INSTABILITY OF VORTON COLLAPSE, UNIVERSE INFLATION AND "DARK MATTER" EXPLAINED.

As we saw in articles Refs.[3-5,29] the system of 3 slightly non-parallel vortons almost perpendicular to 3 vortons plane (approximating 2D vortex dynamics) can start to collapse toward a point. Just before that collapse, however, 3D vorton self-amplification commences and leads to explosive vortons amplitudes and distances growth.

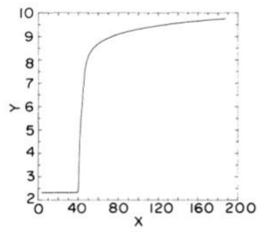


Fig.21

Jump in vorticity during 3 vorton collapse, LOG VORTICITY INTENSITY! against time Refs.(2,3,29). We have the same explosive grows in distances between vortons leading to space explosive inflationary grows and FIRST ORDER PHASE TRANSITION of vacuum compact dimensions to our quasi 3D world Refs.(2,3,29).

This could be a “turbulence” mechanism for the inflationary initial stage of the Universe expansion Refs.[15,29].
More precisely, imagine that the Universe starts as a point singularity fluctuation, and becomes a 2D or 3D turbulent fluid with gravity. In the 2D case gravity will collapse the Universe back to a singularity. However in 3D or quasi-3D/2D+* the vorton amplitudes and distances increase exponentially at the last stage of collapse, see Fig.(21) in Refs.[3-5,29]. This may explain why our world is 3 dimensional!
A quasi 3D frisbee-like world has 2 fully-developed dimensions and 1 short dimension; it might better be described as 2D+ or “frisbee-like”.
In 2D+ frisbee-like space the Universe may be slightly less complex, and have slightly more chances to fluctuate from the original singularity than a fully 3D Universe. And once gravitational collapse explodes in quasi 3D universe it will never get to any more complex spaces. Also quasi 3D/2D+ space may more naturally lead to explosive growth permitting closer vortons approach before 3D stretching and self amplification kicks in an explosive fashion.
However in 2D+/quasi 3D gravitational force decays proportionally to 1/r at a distances from the center of galaxy much larger than the short dimension, instead of 1/r^2 as in 3D.
A universe with two-plus dimensional structure could provide an alternative to “dark matter” as an explanation for anomalous rotation curves in galaxies. It has been observed in the edges of frisbee-like galaxies that star velocities do not depend on distance from the center. Explicitly, setting centripetal acceleration v^2/r equal to gravitational acceleration Constant*M/r, we deduce that v must be constant in such a situation. This is a necessary condition for galactic disk stability Refs.[12,29].

*2D+ universe space could be imagined as two commuting dimensions and third compact one non commuting with first two. In this case initially 2D vortex collapse will become locally 3D in a last moment due to generalized uncertainty principle GUP fluctuations Ref.(46). And explosive vortons self amplification/expansion/inflation will start at the point

of collapse.
“Axes of Evil”/ hemispherical power anomaly Ref.(49) space asymmetry could be explained as confirmation of 2D+ nature of universe. In direction of short dimension we would have less stretching of space than in two larger dimensions directions and thus slightly larger temperature differences/gradients/variance.

SECTION 6. SIMULATION OF VORTEX STRUCTURES DYNAMICS AND NO SLIP BOUNDARY LAYER REF.[3-5]

In this section we show how vorton simulations reproduce vortex structures typically observed in experiments Fig.(1-20).

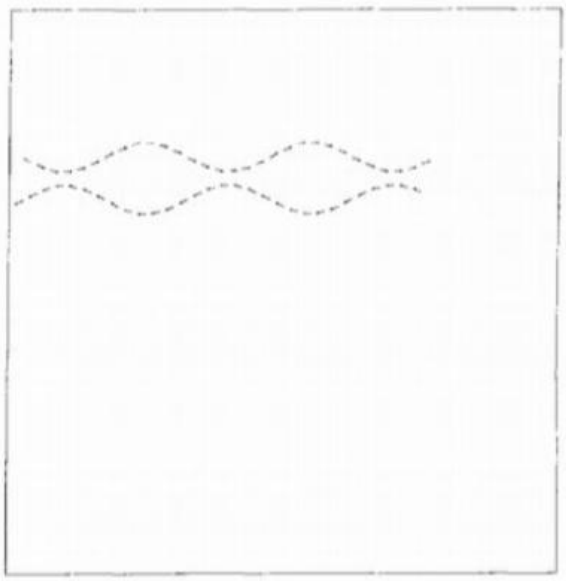


Fig. 13.

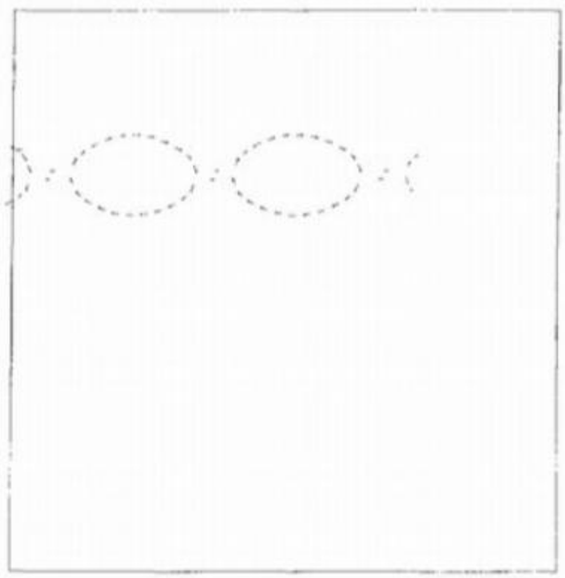


Fig. 14.

Crow instability of vortex tubes behind airplanes Ref. (3-5). Antiparallel perturbed vortex tubes reconnect into vortex rings.

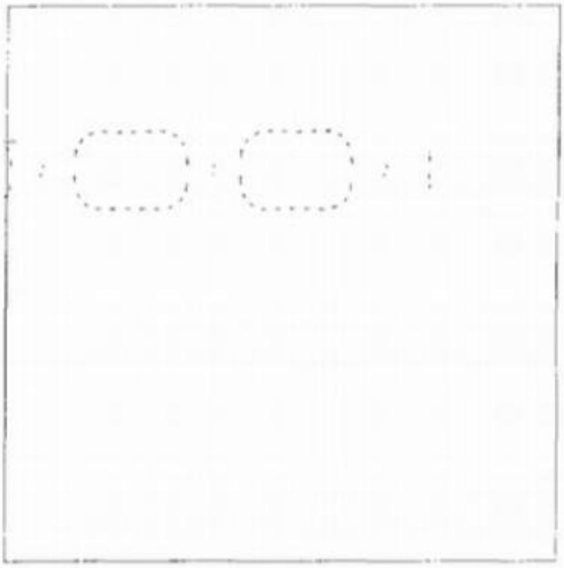


Fig. 15.

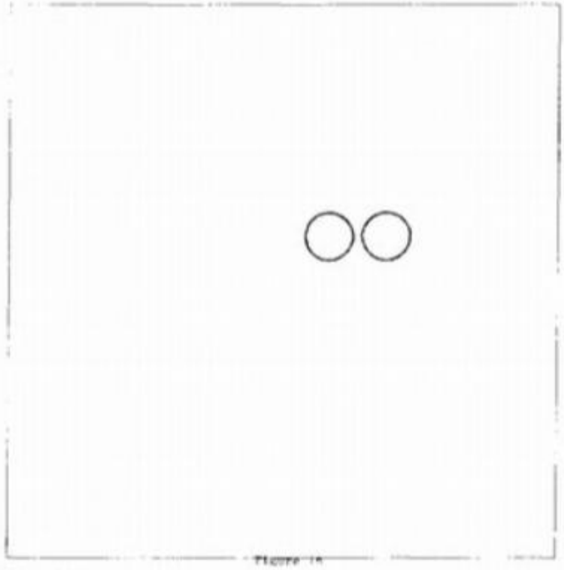


Fig. 16.

Fig. 17.

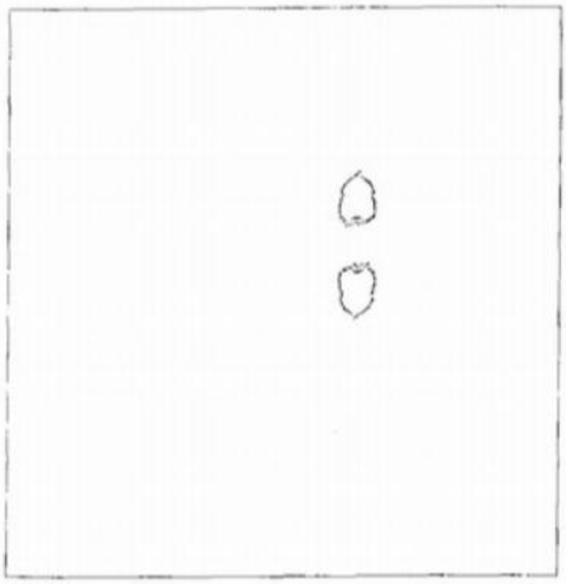


Fig. 18.

Two parallel moving vortex rings merging and splitting in perpendicular direction ref.(3-5).

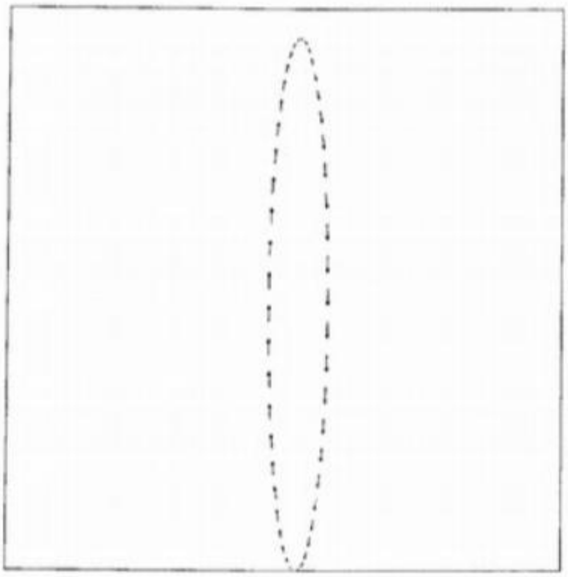


Fig. 11.

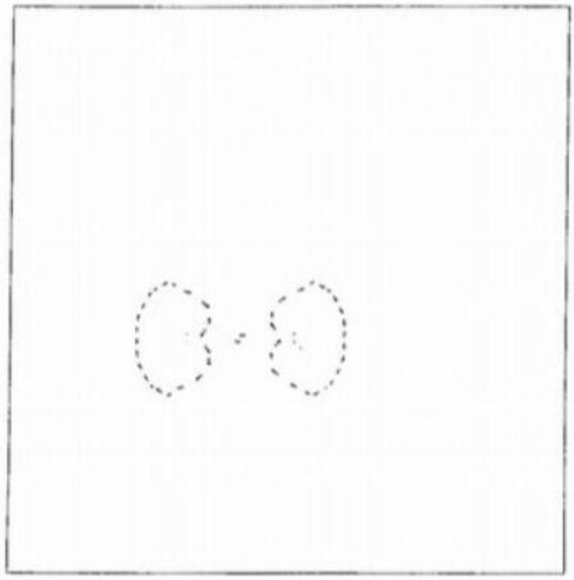


Fig. 12.

Elliptic vorton ring splits into 2 rings in perpendicular direction ref.(3-5).

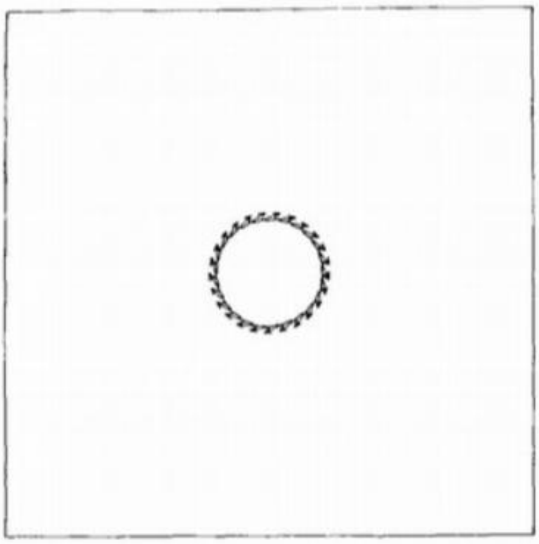


Fig. 3. Reconnections of vortex filaments (see text). The scale of vortex intensities adjusts to the maximal intensity, which increases continuously. The scale of positions does not change.

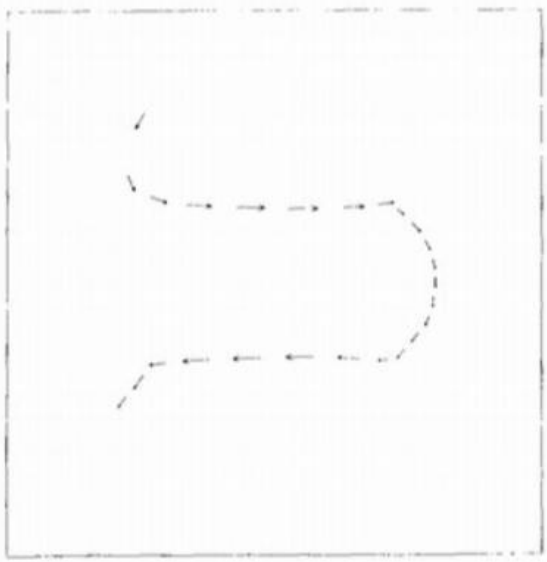


Fig. 4.

Vortex ring approaches boundary under 45 degrees angle and turns into horseshoe vortex Ref.(3-5).

We performed numerical experiments with two vorton rings executing a “leapfrogging” cycle. The rings always self-destructed after 5 periods, regardless of the number of vortons in the rings. Multiple reconnections then happened, with small rings appearing. During the

destruction of the original rings we observed a negative spike in the vorton interaction energy, and a Kolmogorov-like power spectrum developed Eq.(5,6),Fig.(20). This agrees with the physical phenomena of energy transfer to small scales and inviscid dissipation of vorton interaction energy Ref.(3-5).Recent experiments on colliding vortex rings show strikingly similar behavior Ref.[19], with large numbers of vortex reconnections and the appearance of multiple small rings ref.[19].
In wall-bounded flows vorticity is created via no-slip boundary conditions. We represent this process by placing arrays of vorton tubes at a distance from the wall equal to the tube core size and perpendicular to velocity and mirror image vortons to represent boundary Ref.(3-5). The numerical scheme continues to generate vorticity at the wall to keep enforcing the no-slip condition and approximating vortex sheet at no-slip boundary. The numerical experiments show that perturbations on the tubes then expel vortex rings into the flow away from the wall Ref.(3-5),Fig.(5,6).

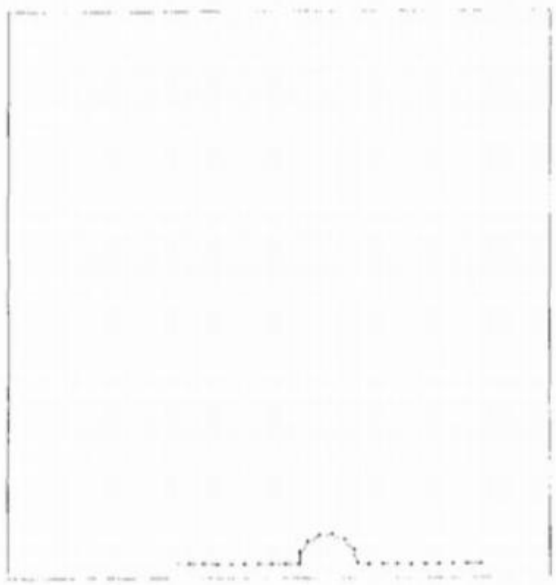


Fig. 5.

Fig. 6.

Perturbed vortex tube near the wall and it expelling vortex ring ref.(3-5).

Using modern fast multipole numerical schemes to simulate vortex dynamics we can come up with number of necessary calculations per time step for boundary layer simulation where typically number of operations proportional to n*ln(n)=(Re^3/4)*ln(Re), when in our case number of vortices/vortons n is **Re^3/4** Ref.[1-5,11].

SECTION 7. FLUID VACUUM MODIFIED NONLINEAR MAXWELL EQUATIONS

The wave functions of elementary particles are often interpreted as probability amplitudes. When they take the form of Gaussian distributions for isolated particle, they look very much like test functions for generalized solutions of unknown nonlinear equations.

Maxwell equations are linear and we don't expect any spontaneous singularities there starting with smooth initial conditions and thus no singular solutions expected there. However if by analogy to previous chapter we assume original vacuum to be very dense and fluid we may modify Maxwell equations for fields and charges to be advected, frozen in fluid vacuum. Thus we have following modified electromagnetism equations,

$$\nabla \cdot \overline{E} = \frac{\rho}{\varepsilon_0} \qquad (7.1)$$

$$\nabla \cdot \overline{B} = 0 \qquad (7.2)$$

$$\nabla \times \overline{E} = -\frac{d\overline{B}}{dt} \qquad (7.3)$$

$$\nabla \times \overline{B} = \mu_0 \left(\bar{J} + \varepsilon_0 \frac{d\overline{E}}{dt}\right) \quad (7.4)$$

$$\frac{d\rho}{dt} = 0 \quad (7.5)$$

$$\frac{d\bar{J}}{dt} = 0 \quad (7.6)$$

$$\frac{d\overline{V}}{dt} = -\nabla \left[\frac{\propto}{2}\left(\varepsilon_0 E^2 + \frac{B^2}{\mu_0}\right) + \frac{g^2}{8\pi G}\right] \quad (7.7)$$

$$\nabla \cdot \overline{V} = 0 \qquad (7.8)$$

Where in original Maxwell equations we substituted total/advective derivatives Refs. (37,29) instead of partial time derivatives and all the fields and charges are frozen in vacuum fluid and being advected.
Vacuum itself satisfies incompressible Euler equation Refs.(37,29) (only transverse waves propagate there). And Euler equation (7.7) represents in right hand side gradient of energy density/dynamic pressure Refs.(36,37) of electromagnetic and gravity fields. And alpha is electromagnetic coupling constant (around 1/173), which originally could have been closer to 1.
After instability/inflation/First order phase transition of vorton collapse created quasi 3D space out of original curled/compact vacuum dimensions we could observe that 3D Euler equation with vorticity develops spontaneous vortex like singularities Refs.(6-8) due to nonlinear stretching/self amplification on time scale of vortex rotation. Also above nonlinear Maxwell equations transform into weak/integral form Ref.(32) with corresponding smooth test functions. As a consequence electromagnetic field and charges also become singular being subject to the same rate of strain as vorticity and being frozen into vacuum fluid.
As a final result we have singular/generalised solutions/"particles" with vorticity/spin and singular electric charge or electromagnetic field and with smooth test function distribution which squared could be interpreted as a probability density function.
Charged singularities with vorticity/angular momentum/spin and spatially distributed according to test function develop magnetic moment.
Here we have possible explanation of quantum mechanics properties of elementary particles. More details of actual elementary particles parameters are connected to influence

of remaining compact vacuum dimensions with corresponding symmetries and entanglements and discrete nature of vacuum at the Planck scale.

SECTION 8. GRAVITY AND 3D PHYSICAL SPACE AS A RESULT OF INSTABILITY OF 3D VORTON COLLAPSE /INFLATION

In approximately 10^(-32)sec original compact vacuum space exponentially inflated/expanded by a factor of at least 10^(30) into our current 3D physical space by mechanism of instability of quasi 3D/2D+ vorton collapse that was much faster than a speed of light Refs(41-43) and inflated space went beyond causality horizon of original vacuum space. Thus original compact vacuum space entanglements persisted in our current 3D space, possibly explaining gravity.

Baryonic asymmetry Quark antiquark annihilation happens on 10^(-25)sec time scale and universe inflation happend on 10^(-32)sec time interval which probably explains some quark antiquark initial instantaneous imbalance at 10^(-10) baryons/photons ratio level Ref.(44).
And it could be explained similarly to CMB inhomogeneities as being inflation magnified instant GUP (generalized uncertainty principle) Ref.(46) Gaussian fluctuations of quark antiquark annihilations at the instant right before inflation commenced.
Due to instantaneous snapshot of Gaussian distribution at time scale of inflation 10^(-32)sec we may have instantaneous nonzero skewness and kurtosis moments/cumulants even at the normal fluctuations and appropriate coefficients in Edgeworth Series moments/cumulants expansion by statistical moments Ref.(45). It's next order to CMB Edgeworth expansion which is due to variance in Edgeworth Series, and could be seen in CMB fluctuations results at 10^(-5) level Ref.(45). Here first/variance term in Edgeworth expansion is cancelled because of quark antiquark annihilations both are normally distributed.

SECTION 9. Dark energy and the expansion of the Universe Refs.(24-27). “Antigravity” as an emergent property of vortons nonlinear interaction.

Instability of vorton quasi 3D/2D+ collapse that created our quasi 3D space during inflation/First order phase transition and thus vorticity probably is frozen into the fabric of space and is driving expansion through vorticity/vortons interaction. Plus if space expansion dilutes mass it in turn stretches vorticity filaments frozen into fabric of space and thus amplifying their intensity. If we observe Eq.(6) for vorton interaction energy we can see that in order for that energy to stay limited in spite of unlimited self amplification of vorton intensities we need distances between vortons to keep increasing. That may explain repulsive/”antigravity”/”dark energy” vortons interaction effect.
As we saw in the previous chapters, the instability of 3D vorton collapse leads to self-amplification and explosive expansion of vorton amplitudes and distances Ref.[1- 5,29]. An interesting fact is that until 5 billion years ago the Universe’s expansion was decelerating, but since then the expansion has accelerated Ref.[15]. There is an antagonism between gravity pushing toward contraction and turbulent 3D vorticity interaction pushing toward expansion of Universe. More precisely, the gravitational field consists of monopoles leading

to a 1/r^2 strength falloff. Meanwhile vorticity is a dipole or quadrupole field with falloff proportional to 1/r^3 or faster. So in the early Universe gravity dominated vorticity interactions. But later vorticity self-amplification due to 3D stretching led to dominance of the vorticity interactions and accelerated the Universe's expansion, with gravity having no self amplification mechanism due to linearity of corresponding equations. This observation is attributed to a mysterious "Dark Energy", which may simply be a manifestation of vorton self and interaction energy. In section 1 we interpreted the infinite self-energy as belonging to unresolved internal rotational degrees of freedom of individual vortons. So the dark energy responsible for the accelerating Universe expansion is simply the transfer of internal rotational energy into interaction energy of the system of vortons plus the transfer of gravitational potential energy in there. Gravity by squeezing vorticity closer intensifies vortex interaction and stretching, self amplification and thus vorton interaction energy .

Energy is conserved. As the vorton interaction energy, and thus dark energy, increases, we expect a corresponding decrease in gravitational interaction/potential energy. In the 3D case the gravitational potential energy of universe **is -(const)*(M^2)/r**, while in the 2D it is (**const)*(M^2)* ln(r)**, where M is universe's gravitationally interacting mass and r is its radius Ref.[20] and constants obviously are not the same. In the intermediate 2+D case we may be closer to the 2D or 3D formula depending on how much the third short dimension is developed compared to the two fully developed dimensions.
In fact we have age of universe about 14B years and visible universe about 46B light years which means mass dilution of currently gravitationally interacting universe mass of about 35 times due to expansion faster than a speed of light Ref.(38), which means that potential gravitational energy of universe decreases with time leading to corresponding increase in vortons/turbulence interaction energy.

Dilution of mass density due to rapid expansion obviously decreases universe contraction factor in Einstein field equation Ref.(35). Space expansion on the other hand stretches/amplifies vorticity/vorton filaments, which are frozen into the fabric of space due to them creating our universe space in a first place by quasi 3D vorton collapse instability/inflation.
By inspection Eq. (6) for vortons interaction energy we can see that vorton interaction energy is proportional to intensities squared and inversely proportional to distances between vortons. In expanding universe as we pointed above, vortons intensities grow linearly as well as distances grow linearly proportionally to universe expansion rate. Thus total interaction energy end up growing linearly with distances in expanding universe by above equation.

We also suspect that the short dimension became more fully developed 5B years ago when the Universe expansion changed from decelerating to accelerating. The gravitational energy released from expansion "regime shift" went into the interaction energy of vortons associated with "dark energy". The above mentioned gravitational potential energy formula then became closer to the 3D case.
Also in fully 3D physical space case as compared to 2+D case we have much stronger vorticity stretching with corresponding vorticity intensity self amplification and with commensurate vortons interaction energy increase. So that central part of frisbee like

universe may expand faster than the rest leading to short dimension approaching two larger dimensions.
Aforementioned expansion rate variability may explain so called “Hubble tension” Ref.(48).

SECTION 10. EARLY BIFURCATION/REGIME SHIFT DETECTION IN NON EQUILIBRIUM NONSTATIONARY SYSTEMS USING LINEAR STATISTICAL MOMENTS APPROXIMATIONS/EQUIVALENTS FORMULAS.

As we saw in Section.7 were regime shift Ref.(40) happened between universe decelerated to accelerated expansion, we need algorithm for early detection in such situations. Every physicist, climatologist, statistician, economist, and market trader hopes to being able to predict bifurcations/regime shifts in the non equilibrium non stationary systems they're studying. Climate, for example, may undergo sudden dramatic change/regime shift which obviously needs early detection. Or Gulf Stream may suddenly disappear with NORTHERN EUROPE TURNING INTO SIBERIA!
Of course perfect prediction is impossible, but early detection of indications could still be very useful. Metrics used for detection have included statistical moments such as standard deviation, skewness, and kurtosis. A problem with these metrics is that they are defined as higher degree polynomials Ref.(28). The calculations require many data points for high accuracy. By the time these metrics are reliably calculated they may no longer be useful for detection. Taking data more frequently does not help, as a system may have different dynamics at different time scales.
An alternative approach is to use approximations/equivalents to higher order moments, that are first order but still capable of capturing volatility, asymmetry, and tails spread characteristics of the distribution.

1. Standard deviation.
a. IQR,
b. Range=(H-L),
c.(H-L)/(H+L).

2. Skewness:
a.(Q(75%)+Q(25%)-2*median))/IQR
b. (H+L-2*median)/(H-L)
c. (mean-median)/IQR

3. Kurtosis
(H-L)/IQR

Where IQR is interquantile range Ref.(30), H an L are process interval high and low, Q(%) is corresponding percentage quantile.
We may add measure of stationarity of the process,
Variance=Std^2.
And the ratio of variances for double time interval and original time interval will be 2 for random walk and 1 for stationary process (assuming constant normalized standard deviation). With our real process at hand somewhere in between.

We may have two uses for above formulas:
1. As a regime shift detected manually.
2. As an automated switch made by some ML system with all above indicators given as an input.
In both cases expert system then may start training on our system historical data assuming relative statistical stability, stationarity and ergodicity Ref.(34) of data between system bifurcations/regime shifts.
Metrics used for detection have included statistical moments such as standard deviation, skewness, and kurtosis, high and low, which are important integral statistical characteristics of a whole time interval of the process.
Again most of real world systems are “open” systems with energy/information exchange with outside, thus we don’t expect stationarity/equilibrium/mean reversion and they will bifurcate and switch regime and in our case of only statistical description of these systems we have to settle to early statistical detection of those shifts.

SECTION 11: CONCLUSSIONS AND DISCUSSION

Using “vortons”, i.e. discrete solenoid vortex dipole elements, essentially solves the problem of the most economical description 3D Navier Stokes equations and their solutions at Reynolds numbers above few thousands. Vortons most economically, irreducibly describe the physics of 3D vortex and magnetic vortex structures, providing dynamics on inviscid 3D Navier Stokes attractor scaling with corresponding Reynolds number. Instability/”inflation” of vorton collapse in quasi 3D space is proposed as an explanation of aspects of the origin of the Universe and phenomena attributed to “dark matter” and “dark energy” Refs.(29,39). Magnetic vortons provide dynamics of combined vortex and magnetic tubes in plasma including reconnections. No-slip boundary shown as a source of vorticity at the boundary and inside the flow. Plus in the process of self distraction of 2 leapfrogging vortex rings and subsequent reconnections we observed Kolmogorov like power law energy spectrum and energy cascade towards small scales.
In terms of cosmology results vorton system provides unique self amplification explosive nonlinear mechanism to explain early universe inflation/First order phase transition and current accelerated expansion with extra bonus of purely dimensional explanation of dark matter without need for dark matter detection efforts. Also it explains results of MOND gravity theory, based on space dimensional structure, which similarly implicitly assumes 1/R gravity force in galaxies far from the center. And finally First order phase transition/inflation of original compact vacuum space to our quasi 3D physical space during universe explosive expansion leads to fluid vacuum induced appearance of spontaneous singularities in electromagnetism and weak/integral formulation which in turn explains appearance of elementary particles and their probabilistic distribution based on test function of generalized/weak solutions of fluid vacuum modified nonlinear Maxwell Equations.
Spontaneus singularities in Navier Stokes and Euler equations lead to original smooth initial conditions turning into many body/” interacting singularities” problem.

Simple linear algorithm suggested for Early Bifurcation/Regime shift detection in nonlinear, non equilibrium, non stationary systems using linear statistical moments approximations/equivalents formulas where used in proprietary statistical programs.

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