This chapter is devoted to the applications of TGD to astrophysics and cosmology.

\vm{\it 1. Many-sheeted cosmology}\vm

The many-sheeted space-time concept, the new view about the relationship between inertial and gravitational four-momenta, the basic properties of the paired cosmic strings, the existence of the limiting temperature, the assumption about the existence of the vapor phase dominated by cosmic strings, and quantum criticality imply a rather detailed picture of the cosmic evolution, which differs from that provided by the standard cosmology in several respects but has also strong resemblances with inflationary scenario.

It should be made clear that many-sheeted cosmology involves a vulnerable assumption. It is assumed that single-sheeted space-time surface is enough to model the cosmology. This need not to be the case. GRT limit of TGD is obtained by lumping together the sheets of many-sheeted space-time to a piece of Minkowski space and endowing it with an effective metric, which is sum of Minkowski metric and deviations of the induced metrics of space-time sheets from Minkowski metric. Hence the proposed models make sense only if GRT limits allowing imbedding as a vacuum extremal of K\"ahler action have special physical role.

The most important differences are following.

\begin{enumerate}

\item Many-sheetedness implies cosmologies inside cosmologies Russian doll like structure with a spectrum of Hubble constants.

\item TGD cosmology is also genuinely quantal: each quantum jump in principle recreates each sub-cosmology in 4-dimensional sense: this makes possible a genuine evolution in cosmological length scales so that the use of anthropic principle to explain why fundamental constants are tuned for life is not necessary.

\item The new view about energy means provided by zero energy
ontology
(ZEO) means that the notion of energy and also other quantum numbers
is
length scale dependent. This allows to understand the apparent
non-conservation of energy in cosmological scales although Poincare
invariance is exact symmetry. In ZEO any cosmology is in principle
creatable from vacuum and the problem of initial values of cosmology
disappears. The density of matter near the initial moment is
dominated
by cosmic strings approaches to zero so that big bang is transformed
to
a silent whisper amplified to a relatively big bang.

\item Dark matter hierarchy with dynamical quantized Planck constant
implies the presence of dark space-time sheets which differ from
non-dark ones in that they define multiple coverings of M^4.
Quantum
coherence of dark matter in the length scale of space-time sheet
involved implies that even in cosmological length scales Universe is
more like a living organism than a thermal soup of particles.

\item Sub-critical and over-critical Robertson-Walker cosmologies
are
fixed completely from the imbeddability requirement apart from a
single
parameter characterizing the duration of the period after which
transition to sub-critical cosmology necessarily occurs. The
fluctuations of the microwave background reflect the quantum
criticality
of the critical period rather than amplification of primordial
fluctuations by exponential expansion. This and also the finite size
of
the space-time sheets predicts deviations from the standard
cosmology.

\end{enumerate}

\vm{\it 2. Cosmic strings}\vm

Cosmic strings belong to the basic extremals of the K\"ahler
action.
The string tension of the cosmic strings is $T\simeq .2\times
10^{-6}/G$ and slightly smaller than the string tension of the GUT
strings and this makes them very interesting cosmologically.
Concerning
the understanding of cosmic strings a decisive breakthrough came
through
the identification of gravitational four-momentum as the difference

of inertial momenta associated with matter and antimatter and the realization that the net inertial energy of the Universe vanishes. This forced to conclude cosmological constant in TGD Universe is non-vanishing. p-Adic length fractality predicts that $\Lambda $ scales as $1/L^2(k)$ as a function of the p-adic scale characterizing the space-time sheet. The recent value of the cosmological constant comes out correctly. The gravitational energy density described by the cosmological constant is identifiable as that associated with topologically condensed cosmic strings and of magnetic flux tubes to which they are gradually transformed during cosmological evolution.

p-Adic fractality and simple quantitative observations lead to the hypothesis that pairs of cosmic strings are responsible for the evolution of astrophysical structures in a very wide length scale range. Large voids with size of order 10^8 light years can be seen as structures containing knotted and linked cosmic string pairs wound around the boundaries of the void. Galaxies correspond to same structure with smaller size and linked around the supra-galactic strings. This conforms with the finding that galaxies tend to be grouped along linear structures. Simple quantitative estimates show that even stars and planets could be seen as structures formed around cosmic strings of appropriate size. Thus Universe could be seen as fractal cosmic necklace consisting of cosmic strings linked like pearls around longer cosmic strings linked like...

\vm{\it 3. Dark matter and quantization of gravitational Planck constant}\vm

The notion of gravitational Planck constant having possibly gigantic values is perhaps the most radical idea related to the astrophysical applications of TGD. D. Da Rocha and Laurent Nottale have proposed that Schr\"odinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant $\hbar_{gr}= \frac{GmM}{v_0}$ ($\hbar=c=1$). v_0 is a velocity parameter having the value $v_0=144.7\pm .7$ km/s giving $v_0/c= 4.6\times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of v_0 seem to appear. The support for

the hypothesis comes from empirical data.

By Equivalence Principle and independence of the gravitational Compton length on particle mass m it is enough to assume g_{gr} only for flux tubes mediating interactions of microscopic objects with central mass M. In TGD framework h_{gr} relates to the hierarchy of Planck constants $h_{eff}=n\times h$ assumed to relate directly to the non-determinism and to the quantum criticality of K\"ahler action.

Dark matter can be identified as large h_{eff} phases at K\"ahler magnetic flux tubes and dark energy as the K\"ahler magnetic energy of these flux tubes carrying monopole magnetic fluxes. No currents are needed to create these magnetic fields, which explains the presence of magnetic fields in cosmological scales.

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