Abstracts of Award Winning and Honorable Mention Essays for 2004

Award Essays

First Award – A Secret Tunnel through the Horizon – by Maulik Parikh, Department of Physics, Columbia University, New York, NY 10027.

Abstract – Hawking radiation is often intuitively visualized as particles that have tunneled across the horizon. Yet, at first sight, it is not apparent where the barrier is. Here the author shows that the barrier depends on the tunneling particle itself. The key is to implement energy conservation, so that the black hole contracts during the process of radiation. A direct consequence is that the radiation spectrum cannot be strictly thermal. The correction to the thermal spectrum is of precisely the form that one would expect from an underlying unitary quantum theory. This may have profound implications for the black hole information puzzle.

Second Award – Probing Gravitational Interactions of Elementary Particles – by Jonathan L. Feng, Arvind Rajaraman, and Fumihiro Takayama, Department of Physics and Astronomy, University of California, Irvine, CA 92697.

Abstract – The gravitational interactions of elementary particles are suppressed by the Planck scale $M_* \sim 10^{18}$ GeV and are typically expected to be far too weak to be probed by experiments. The authors show that, contrary to conventional wisdom, such interactions may be studied by particle physics experiments in the next few years. As an example, they consider conventional supergravity with a stable gravitino as the lightest supersymmetric particle. The next-lightest supersymmetric particle (NLSP) decays to the gravitino through gravitational interactions after about a year. This lifetime can be measured by stopping NLSPs at colliders and observing their decays. Such studies will yield a measurement of Newton's gravitational constant on unprecedented small scales, shed light on dark matter, and provide a window on the early universe.

Third Award – Charge Conjugation and Lense-Thirring Effect – A New Asymmetry – by D.V. Ahluwalia-Khalilova, ISGBG, Ap. Postal C-600, Department of Mathematics, University of Zacatecas (UAZ), Zacatecas, Zacatecas 98060, Mexico.

Abstract – This essay presents a new asymmetry that arises from the interplay of charge conjugation and the Lense-Thirring effect. When applied to Majorana neutrinos, the effects predict $\nu_e \Leftrightarrow \overline{\nu}_e$ oscillations in gravitational environments with rotating sources. Parameters associated with astrophysical environments indicate that the presented effect is presently unobservable for solar neutrinos. But, it will play an important role in supernovae explosions and carries relevance for the observed matter-antimatter asymmetry in the universe.

Fourth Award – The Quantum Gravitational Black Hole is Neither Black Nor White – by T.P. Singh[*] and Cenalo Vaz[#], [*]Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400 005, India; [#]Department of Physics, University of Cincinnati, Cincinnati, OH 45221.

Abstract – Understanding the end state of black hole evaporation, the microscopic origin of black hole entropy, the information loss paradox, and the nature of the singularity arising in gravitational collapse – these are outstanding challenges for any candidate quantum theory of gravity. Recently, a midisuperspace model of quantum gravitational collapse has been solved using a lattice regularization scheme. It is shown that the mass of an eternal black hole follows the Bekenstein spectrum; a related argument provides a fairly accurate estimate of the entropy. The solution also describes a quantized mass-energy distribution around a central black hole, which in the WKB approximation, is precisely Hawking radiation. The leading quantum gravitational correction makes the spectrum non-thermal, thus providing a plausible resolution of the information loss problem.

Fifth Award – Quantum Field Theory Is Not Merely Quantum Mechanics Applied to Low Energy Effective Degrees of Freedom – by Stefan Hollands and Robert M. Wald, Enrico Fermi Institute and Department of Physics, University of Chicago, 5640 S. Ellis Ave., Chicago, IL 60637.

Abstract – It is commonly assumed that quantum field theory arises by applying ordinary quantum mechanics to the low energy effective degrees of freedom of a more fundamental theory defined at ultra-high-energy/short-wavelength scales. The authors argue here that, even for free quantum fields, there are holistic aspects of quantum field theory that cannot be properly understood in this manner. Specifically, the “subtractions” needed to define nonlinear polynomial functions of a free quantum field in curved spacetime are quite simple and natural from the quantum field theoretic point of view but are, at best, extremely ad hoc and unnatural if viewed as independent renormalizations of individual modes of the field. This point is illustrated by contrasting the analysis of the Casimir effect, the renormalization of the stress-energy tensor in time-dependent spacetimes, and anomalies from the point of quantum field theory and from the point of view of quantum mechanics applied to the independent low energy modes of the field. Some implications for the cosmological constant problem are discussed.

Honorable Mention Awards (Alphabetical Order)

1. Cosmological Term and Fundamental Physics – by R. Aldrovandi, J.P. Almeida, and J.G. Pereira, Instituto de Física Teórica, Universidade Estadual Paulista, Rua Pamplona 145, 01405-900 São Paulo, Brazil.

Abstract – A non-vanishing cosmological term in Einstein's equations implies a non-vanishing spacetime curvature even in the absence of any kind of matter. It would, as a consequence, affect many of the underlying kinematic tenets of physical theory. The usual commutative spacetime translations of the Poincaré group would be replaced by the mixed conformal translations of the de Sitter group, leading to obvious alterations in elementary concepts such as time, energy and momentum. Although negligible at small scales, such modifications may come to have important consequences both in the large and for the inflationary picture of the early Universe. A qualitative discussion is presented which suggests deep changes in Hamiltonian, Quantum and Statistical Mechanics. In the primeval universe as described by the standard cosmological model, in particular, the equations of state of the matter sources could be quite different from those usually introduced.

2. A Glimpse at the Flat-Spacetime Limit of Quantum Gravity Using the Bekenstein Argument in Reverse – by Giovanni Amelino-Camelia[+], Michele Arzano[#], and Andrea Procaccini[+], [+]Dip. Fisica Univ. Roma "La Sapienza" and Sez. Roma1 INFN, Piazzale Moro 2, Roma, Italy; [#]Department of Physics and Astronomy, University of North Carolina, Chapel Hill, NC 27599.

Abstract –An insightful argument for a linear relation between the entropy and the area of a black hole was given by Bekenstein using only the energy-momentum dispersion relation, the uncertainty principle, and some properties of classical black holes. Recent analyses within String Theory and Loop Quantum Gravity describe black-hole entropy in terms of a dominant contribution, which indeed depends linearly on the area, and a leading log-area correction. The authors argue that, by reversing the Bekenstein argument, the log area correction can provide insight on the energy-momentum relation and the uncertainty principle of a quantum-gravity theory. This could be valuable when, as in Loop Quantum Gravity, a description of some quantum properties of black holes is available but there are still no reliable results on the energy-momentum relation.

3. Holographic Cosmology – by T. Banks[*] and W. Fischler[+], [*]Department of Physics and Astronomy – NHETC, Piscataway, NJ 08540 and Department of Physics, SCIPP, University of California, Santa Cruz, CA 95064; [+]Department of Physics, University of Texas, Austin, TX 78712.

Abstract – The authors describe a cosmology of the very early universe, based on the holographic principle of 't Hooft and Susskind. The initial state of the universe is heuristically viewed as a dense black hole fluid. They present a mathematical model of the heuristic picture.

4. A Singular Future – by John D. Barrow, DAMTP, Centre for Mathematical Sciences, Cambridge University, Wilberforce Road, Cambridge CB3 0WA, UK.

Abstract – The author shows that a singularity can occur at a finite future time in an expanding Friedmann universe even when $\rho > 0$ and $\rho+3p > 0$.

5. Expansion, Geometry, and Gravity – by Robert R. Caldwell[*] and Marc Kamionkowski[+], [*]Department of Physics and Astronomy, Dartmouth College, 6127 Wilder Laboratory, Hanover, NH 03755; [+]Mail Code 130-33, California Institute of Technology, Pasadena, CA 91125.

Abstract – In general-relativistic cosmological models, the expansion history, matter content, and geometry are closely intertwined. In this brief paper, the authors clarify the distinction between the effects of geometry and expansion history on the luminosity distance. They show that the cubic correction to the Hubble law, measured recently with high-redshift supernovae, is the first cosmological measurement, apart from the cosmic microwave background, that probes directly the effects of spatial curvature. They illustrate the distinction between geometry and expansion with a toy model for which the supernova results already indicate a curvature radius larger than the Hubble distance.

6. Dark Geometry – by J.A.R. Cembranos, A. Dobado, and A.L. Maroto, Departamento de Física Teórica, Universidad Complutense de Madrid, 28040 Madrid, Spain.

Abstract – Extra-dimensional theories contain additional degrees of freedom related to the geometry of the extra space, which can be interpreted as new particles. Such theories allow the reformulation of most of the fundamental problems of physics from a completely different point of view. In this essay, the authors concentrate on the brane fluctuations which are present in the brane-world and how the oscillations of the space-time geometry along the curved extra dimensions can help to resolve the Universe missing mass problem. The energy scales involved in these models are low compared to the Planck scale. This means that some of the brane fluctuations' distinctive signals could be detected in future colliders and in direct or indirect dark matter searches.

7. Gravitation and the Second Law of Thermodynamics – by Andrew Chamblin[*] and Joshua Erlich[#], [*]Department of Physics, Queen Mary, University of Louisville, Louisville, KY 40292; [#]Department of Physics, Box 351560, University of Washington, Seattle, WA 98195.

Abstract – Just as gravitons can carry energy, they can also be used to transmit information. It follows that an entropy should be associated with gravitational degrees of freedom, independent of the presence or absence of black holes. In this essay, the authors discuss how one might count gravitational entropy given a classical gravitational field. Their suggestion is motivated by a derivation of the covariant entropy bound in which a gravitational term appears naturally.

8. No Black Hole Information Puzzle in a Relational Universe – by Rodolfo Gambini[*], Rafael A. Porto[#], and Jorge Pullin[+], [*]Instituto de Física, Facultad de Ciencias, Iguá 4225, esq. Mataojo, Montevideo, Uruguay; [#]Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213; [#]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803-4001.

Abstract – A relational description of nature appears as the most appropriate at a fundamental level, as has been advocated by many physicists and philosophers throughout history. The introduction of a relational time in quantum gravity naturally implies that pure quantum states evolve into mixed quantum states. The authors show, using a recently proposed concrete implementation, that the rate at which pure states naturally evolve into mixed ones is faster than that due to collapsing into a black hole that later evaporates. This is rather remarkable since the fundamental mechanism for decoherence is usually very weak. Therefore there is no "black hole information puzzle" in a relational universe.

9. The Nature of Gravitational Singularities – by David Garfinkle, Department of Physics, University of Guelph, Guelph, Ontario, Canada N1G 2W1 and Perimeter Institute for Theoretical Physics, 35 King Street North, Waterloo Ontario, Canada N2J 2W9.

Abstract – The nature of gravitational singularities, long mysterious, has now become clear through a combination of mathematical and numerical analysis. As the singularity is approached, the time derivative terms in the field equations dominate and the singularity behaves locally like a homogenous oscillatory spacetime.

10. Towards a Future Singularity? – by M. Gasperini, Dipartimento di Fisica, Università di Bari, Via G. Amendola 173, 70126 Bari, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Bari, Italy.

Abstract – The author discusses whether the future extrapolation of the present cosmological state may lead to a singularity even in the case of "conventional" (negative) pressure of the dark energy field, namely $w = p/\rho \geq -1$. The discussion is based on an often neglected aspect of scalar-tensor models of gravity: the fact that different test particles may follow the geodesics of different metric frames and the need for a frame-independent regularization of curvature singularities.

11. Quantum Effects and Superquintessence in the New Age of Precision Cosmology – by E Gunzig[*] and Alberto Saa[#], [*]RggR, Université Libre de Bruxelles, CP 231, 1050 Bruxelles, Belgium; [#]IMECC – UNICAMP, C.P. 6065, 13081-970 Campinas, SP, Brazil.

Abstract – Recent observations of Type Ia supernova at high redshifts establish that the dark energy component of the universe has (a probably constant) ratio between pressure and energy density $w = p/\rho = -1.02\left(^{+0.13}_{-0.19}\right)$. The conventional quintessence models for dark energy are restricted to the range $-1 \leq w < 0$, with the cosmological constant corresponding to $w = -1$. Conformally coupled quintessence models are the simplest ones compatible with the marginally allowed superaccelerated regime ($w < -1$). However, they are known to be plagued with anisotropic singularities. The authors argue here that the extension of the classical approach to the semi-classical one, with the inclusion of quantum counterterms necessary to ensure the renormalization, can eliminate the anisotropic singularities preserving the isotropic behavior of conformally coupled superquintessence models. Hence, besides having other interesting properties, they are consistent candidates to describe the superaccelerated phases of the universe compatible with the present experimental data.

12. Quantum Nature of Black Holes – by Adam D. Helfer, Department of Mathematics, University of Missouri, Columbia, MO 65211.

Abstract – The author reconsiders Hawking's analysis of the effects of gravitational collapse on quantum fields, taking into account interactions between the fields. The ultra-high energy vacuum fluctuations, which had been considered to be an awkward peripheral feature of the analysis, are shown to play a key role. By interactions, they can scatter particles to, or create pairs of particles at, ultra-high energies. The energies rapidly become so great that quantum gravity must play a dominant role. Thus the vicinities of black holes are essentially quantum-gravitational regimes.

13. Toward a Background Independent Quantum Theory of Gravity – by Vishnu Jejjala, Djordje Minic, and Chia-Hsiung Tze, Institute for Particle Physics and Astrophysics, Physics Department, Virginia Tech, Blacksburg, VA 24061.

Abstract – Any canonical quantum theory can be understood to arise from the compatibility of the statistical geometry of distinguishable observations with the canonical Poisson structure of Hamiltonian dynamics. This geometric perspective offers a novel, background independent non-perturbative formulation of quantum gravity. The authors invoke a quantum version of the equivalence principle, which requires both the statistical and symplectic geometries of canonical quantum theory to be fully dynamical quantities. Their approach sheds new light on such basic issues of quantum gravity as the nature of observables, the problem of time, and the physics of the vacuum. In particular, the observed numerical smallness of the cosmological constant can be rationalized in this approach.

14. Lorentz Violation and Quantum Gravity – by V. Alan Kostelecký, Physics Department, Indiana University, Bloomington, IN 47405.

Abstract – Lorentz symmetry lies at the heart of relativity and is a feature of low-energy descriptions of nature. Minuscule Lorentz-violating effects arising in theories of quantum gravity offer a promising candidate signal for new physics at the Planck scale. A framework is presented for incorporating arbitrary Lorentz violation into general relativity and other theories of gravity. Applying this framework yields a proof that explicit Lorentz symmetry breaking is incompatible with generic Riemann-Cartan geometries. The framework also enables the direct construction of all possible dominant and sub-dominant Lorentz-violating terms in the effective low-energy action for quantum gravity, which provides a comprehensive guide to searches for observable phenomena.

15. A Viscosity Bound Conjecture – by P. Kovtun[*], D.T. Son[#], and A.O. Starinets[#], [*]Department of Physics, University of Washington, Seattle, WA 98195-1560; [#]Institute for Nuclear Theory, University of Washington, Seattle, WA 98195-1550.

Abstract – Exploring an extension of the correspondence between black hole physics and thermodynamics to non-equilibrium processes, the authors show that the ratio of shear viscosity to volume density of entropy in theories with gravity duals is equal to a universal value of $\hbar/(4\pi)$. They conjecture that this value serves as a lower limit on the ratio of shear viscosity to entropy density for all systems realizable in Nature.

16. Fueling Cosmic Acceleration with Alternative Gravities – by Arthur Lue[*], Roman Scoccimarro[#], and Glenn D. Starkman[*], [*]Center for Education and Research in Cosmology and Astrophysics, Department of Physics, Case Western Reserve University, Cleveland, OH 44106-7079 and CERN Physics Department, Theory Division, CH-1211 Geneva 23, Switzerland; [#]Center for Cosmology and Particle Physics, Department of Physics, New York University, New York, NY 10003.

Abstract – The authors entertain the intriguing possibility that the contemporary cosmic acceleration is not the manifestation of yet another mysterious ingredient in the cosmic gas tank (dark energy), but rather it is our first real lack of understanding of gravity itself and even possibly a signal that there might exist dimensions beyond that which we can currently observe. When gravity is altered as an engine for cosmological expansion it is inevitably altered as a communicator of universal attraction. The most exciting part of this new line of study is the possibility of concretely testing these outrageous ideas with imminent observational data.

17. 2-D or not 2-D? Breaking the Shackles of Holography – by Donald Marolf, Department of Physics, MS 9530, University of California, Santa Barbara, CA 93106.

Abstract – There is wide belief in "the holographic principle" – the claim that the fundamental description of our universe resides in less that 3+1 dimensions and contains one bit of information per Planck area. But is it well-founded? This essay points out loopholes in the common pro-holography arguments in an attempt to encourage young physicists to think more broadly and to generate new non-holographic ideas.

18. On the Nature of Dark Matter – by Tonatiuh Matos[*] and L. Arturo Ureña-López[#], [*]Departamento de Física, Centro de Investigación y de Estudios Avanzados del IPN, A.P. 14-740, 07000 México D. F., México; [#]Instituto de Física de la Universidad de Guanajuato, A.P. 150, 37150, León, Guanajuato, México.

Abstract – Dark matter in the universe seems to be one of the most important puzzles science has to face at this moment. In this essay the authors point out that dark matter could be a spin-0 fundamental interaction of Nature rather than a simple particle. From this hypothesis follows that dark matter behaves just as standard cold dark matter at the cosmological level while still in good agreement with observations at galactic scales. This new interaction could be one of the scalar fields predicted by higher-dimensional theories.

19. Gravity as Elasticity of Spacetime: a Paradigm to Understand Horizon Thermodynamics and Cosmological Constant – by T. Padmanabhan, IUCAA, Post Bag 4, Ganeshkhind, Pune – 411 007, India.

Abstract – It is very likely that the quantum description of spacetime is quite different from what we perceive at large scales, $l >> (G\hbar/c^3)^{1/2}$. The long wavelength description of spacetime, based on Einstein's equations, is similar to the description of a continuum solid made of a large number of microscopic degrees of freedom. This paradigm provides a novel interpretation of coordinate transformations as deformations of "spacetime solid" and allows one to obtain Einstein's equations as a consistency condition in the long wavelength limit. The entropy contributed by the microscopic degrees of freedom reduces to a pure surface contribution when Einstein's equations are satisfied. The horizons arise as "defects" in the "spacetime solid" (in the sense of well defined singular points) and contribute an entropy which is one quarter of the horizon area. Finally, the response of the microstructure to vacuum energy leads to a near cancellation of the cosmological constant, leaving behind a tiny fluctuation which matches with the observed value.

20. Speed of Gravity and Gravitomagnetism – by J.-F. Pascual-Sánchez, Dept. Matemática Aplicada, Facultad de Ciencias, Universidad de Valladolid, 47005, Valladolid, Spain.

Abstract – The existence of a v_J/c correction to the Shapiro time delay seems verified by a 2002 Jovian observation by VLBI. In this essay, this correction is interpreted not as a measurement of the speed of gravity, as was first proposed, but as an effect of the aberration of light in an optically refractive medium which supplies an analog of Jupiter's gravity field. The variation of the index of refraction is induced by the Lorentz invariance of the weak gravitational field equations for Jupiter in uniform translational slow motion. The correction on time delay and deflection is not due to the Kerr (or Lense-Thirring) stationary gravitomagnetic field of Jupiter but to its Schwarschild static one when it is measured from the barycenter of the solar system.

21. Repelled By Gravity – by Fabrizio Pinto, InterStellar Technologies Corporation, 115 North Fifth Avenue, Monrovia, CA 91016.

Abstract – The author shows that a pair of interacting hydrogenic atoms immersed in a gravitational field undergoes an additional force ultimately linked to the distortion of the unretarded electrostatic dipole-dipole potential in curved space-time. The effect of this force on a molecular pair is relatively small, although well within range of present-day atom interferometric experiments. Then he proceeds to discuss the expected modification of the intermolecular potential caused by intense laser illumination in curved space-time. By adopting illumination strategies known to produce long-range, "gravity-like" interactions among atoms in trapped, cold gases, he shows that the effect discussed herein can be both modulated and vastly magnified so that it is realistic to consider the possibility that such a many-body system could be brought to a hover or even repelled by the gravitational field.

22. The Low Mass Progenitor of the Binary Pulsar J0737-3039B – Evidence for a New Type of Stellar Collapse – by Tsvi Piran and Nir J. Shaviv, Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem 91904, Israel.

Abstract – Evolutionary scenarios suggest that the progenitor of the new binary pulsar J0737-3039B was a He-star with $M > 2.1\text{-}2.3M_{\odot}$. The authors show in this case that the binary must have a large (> 120km/sec) center of mass velocity. However, the location, ~50pc from the Galactic plane, implies that they system has, at high likelihood, a significantly smaller center of mass velocity and a progenitor more massive than $2.1M_{\odot}$ is ruled out (at 97% confidence). A progenitor mass around $1.45M_{\odot}$, involving a new previously unseen gravitational collapse, is kinematically favored. Proper motion measurements would enable us to distinguish between the two scenarios within a year.

23. Stabilization of a Relativistic Degenerate Star Beyond the Chandrasekhar Mass Limit – by M.P. Silverman, Departments of Physics and Astronomy, Trinity College, Hartford, CT 06070.

Abstract – In contrast to the widely held belief that a degenerate star that has exhausted its nuclear fuel will, if sufficiently massive, unremittingly collapse to a singularity in space (unless the contraction is prevented by some unknown process of quantum gravity acting at the scale of the Planck length), the author presents a heuristic argument, based on known quantum processes, for the existence of stable equilibrium states of neutron stars and quark stars with macroscopic radii and masses unconstrained by the Chandrasekhar limit. The processes that stabilize the star against gravitational contraction involve strong magnetic coupling of the constituent fermions and fermionic pair production at the expense of gravitational potential energy.

24. Multidimensional Black Objects – Evgeny Sorkin, The Racah Institute of Physics, The Hebrew University, Jerusalem, Israel, 91904.

Abstract – In the presence of extra compact dimensions the black hole solutions of General Relativity are dramatically different from those in 4D. "Black Objects" with various horizon topology exist, depending on the size of the black object and the compactification lengths. Phase transitions between them arise and touch on fundamental issues of uniqueness, topology change and cosmic censorship. Here the author estimates under what conditions these black objects become unstable. He finds that there are critical dimensions below which the transitions between various black objects are of first order (potentially violating the cosmic censorship and accompanied by explosions) while above it the transitions are continuous. Moreover, he finds the topology of the extra-dimensional space to be a vital ingredient indicating that in the presence of several compact dimensions the transitions are generically smooth.

25. Exploring Fifth Force Interactions with 18th Century Technology – by Jason H. Steffen, University of Washington at Seattle, P.O. Box 351560, Seattle, WA 98195-1560.

Abstract – Many theories which unify gravity with the other known forces of nature predict the existence of an intermediate-range "fifth force" similar to gravity. Such a force would be manifest as a deviation from the gravitational inverse-square law. Currently, at distances near $10^{-1}m$, the inverse-square law is known to be correct to about one part per thousand. The author presents the design of an experiment that will improve this limit by two orders of magnitude. This is accomplished by constructing a torsion pendulum and source mass apparatus that are particularly insensitive to Newtonian gravity and, simultaneously, maximally sensitive to violations of the same.

26. Gravito-Electromagnetism: Glimpses of Unexplored Deep Connections – by C.S. Unnikrishnan[*] and G.T. Gillies[#], [*]Gravitational Group, Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai – 400 005, India; [#]School of Engineering and Applied Science, University of Virginia, Charlottesville, VA 22904-4746.

Abstract – In this essay, the authors discuss a program to explore experimentally some connections between gravity and electromagnetism, not yet adequately studied. Some of the key issues they address are the complete absence of gravity for electrons inside a metal drift tube (Schiff-Barnhill effect), and its rotational variant, the Schuster-Blackett relation between rotation of neutral matter and generation of magnetic fields and a variation of the Faraday unipolar induction. These experiments that probe macroscopic, low energy, and seemingly classical aspects, have the potential to reveal underlying microscopic, high energy, unification-scale quantum connections between gravity and electromagnetism

27. In Quest of a True Model of the Universe – by R.G. Vishwakarma, Department of Mathematics, Autonomous University of Zacatecas, Zacatecas, ZAC C.P. 98060, Mexico.

Abstract – In order to explain the high-redshift supernovae Ia observations together with the recently made precise observations of the CMB anisotropy by WMAP, the standard big bang cosmology has to invoke some hypothetical matter with unnatural properties which is very speculative. This casts doubts upon the foundations of the standard cosmology and suggests that some theoretical concept may still be missing from the theory. Such a concept might be the energy associated with the rotation of the astronomical objects which has not been taken into account properly before. It is shown that if the energy associated with the rotation of massive galaxies is taken into account, one can have $\Omega_{total} \approx 1$ without invoking the hypothetical dark matter or dark energy. This picture also appears consistent with the recent observations of a great abundance of old massive galaxies made by Gemini Deep Deep Survey.