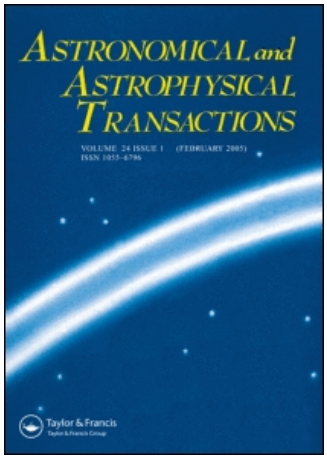

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Naturalness of the singularities in gravitation and cosmology

R. F. Polishchuk [a]
[a] Astro-Space Centre, P. N. Lebedev Physical Institute, Moscow

Online Publication Date: 01 January 1994
To cite this Article: Polishchuk, R. F. (1994) 'Naturalness of the singularities in gravitation and cosmology', Astronomical & Astrophysical Transactions, 5:1, 91 - 92
To link to this article: DOI: 10.1080/10556799408245860
URL: http://dx.doi.org/10.1080/10556799408245860

Astronomical and Astrophysical Transactions, 1994, Vol. 5, pp. 91–92
Reprints available directly from the publisher.
Photocopying permitted by license only

NATURALNESS OF THE SINGULARITIES IN GRAVITATION AND COSMOLOGY

R. F. POLISHCHUK

Astro-Space Centre, P. N. Lebedev Physical Institute, Moscow

(16 December 1992)

A. L. Zel'manov hoped that the factors of homogeneity and anisotropy would allow singularities to be avoided in the cosmological models and a regular minimum to be provided [1]. Hawking and Penrose proved the theorem on the inevitability of singularities, if a trap surface is available [2]. It remains unclear, how natural are such surfaces.

General Relativity starts from Einstein's equations $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi T_{\mu\nu}$ ($\mu = 0, i$), wherein the Einstein tensor is put equal to the matter one. They are generally diagonalizable:

$$T_{\mu\nu} = -p_0 u^0_\mu u^0_\nu + p_i u^i_\mu u^i_\nu, \qquad i = 1, 2, 3.$$

The matter tensor and its proper tetrad u^a_μ (a is the Lorentzian index) as well as the eigenvalues p_0 (the matter density in a frame of reference comoving at velocity u^μ_0) and p_i (the pressures along the principal axes of the matter tensor) are defined by the metrics through the Einstein tensor. The conservation law $\nabla_\mu T^{\mu\nu} = 0$ allows an integral formulation [3]:

$$\int_{\Sigma(s)} p_0 \exp\left(-\int_0^s p_0^{-1} p_i a^i_\mu u^\mu_0 \, ds\right)\sqrt{h}\, d^3x = \text{const}.$$

Here $\Sigma(s)$ are the equidistant cuts $s = \text{const}$ of a u_0-world-line tube of the medium with a proper time s, a^i_μ are the u_i-line curvature vectors, $\sqrt{h}\, d^3x$ are the medium volume elements. Like integrals are conserved along the u_i-lines. Since the conserving Einstein tensor describes a focusing of 3-volumes, this law means the conservation of the 3-volume deformation, but not the volumes themselves. Thus, the stereotypes of Special Relativity are not operative in General Relativity, and the conservation laws should be related to the proper axes of the Ricci tensor $R_{\mu\nu}$, but not to the Killing vectors.

It is a positive focusing of the 3-volumes that is provided by the strong conditions of energodominance ($R_{00} \geqslant 0$, $|T_{00}| \geqslant |T_{0i}|$). The positivity of gravity is clearly seen in a semiharmonic frame of reference ($N \equiv \sqrt{-g_{00}} = \sqrt{h}$, $g_{0i} = 0$, $\nabla_\mu \nabla^\mu t = 0$). The first Einstein equation takes the form $\nabla_\mu \nabla^\mu \varphi = 4\pi\rho \geqslant 0$, where $\varphi = -\ln N$, ρ contains the quantities p_a, the space deformation and the observer's acceleration. Therewith $\rho = 0$ only in a flat world [4]. Near the extreme surface $t = 0$ we have $N = \sqrt{h} \approx 1 - 2\pi\rho t^2$, i.e., a contraction of time ($ds = N\, dt \leqslant dt$) and

space. The gravitation reduces to the splitting of time into a proper and harmonic ones. A positive contraction of the volumes naturally leads to the singularities and black holes. An example of a black hole is the Schwarzschild solution. We have for it [5]:

$$\nabla_\lambda R_{\mu\nu\alpha\beta} \cdot \nabla^\lambda R^{\mu\nu\alpha\beta} = -432m^2 r^{-9}(r - 2m).$$

The pole $r = 0$ of this 3rd order curvature invariant marks the central singularity, and the vanishing of the invariant $r = 2m$ marks the boundary of the black hole. Charged and spinning black holes allow description (unnoticed in the literature) in terms of higher order curvature invariants.

The black holes in astronomy are of importance for the scales: of the Universe (the cosmological singularity), stars (a result of a massive star evolution), and microscales (virtual black holes formed in the quantum vacuum fluctuations). The singularities mark the boundary of modern physical theory being applied and of modern physical world existing. They stimulate the creation of new theories and new worlds as well. It is not impossible that Zel'manov's idea of a regular minimum will appear to be operative at the microlevel connecting the old and new worlds without a holocaust.

References

1. Zel'manov, A. L. (1944). PhD thesis. Moscow State University.
2. Hawking, S. W. and Penrose R. (1970). *Proc. Roy. Soc. London*, v. A314, p. 529.
3. Polishchuk, R. F. (1988). V. Marcel Grossmann Meeting. Pert, Australia, p. 62.
4. Polishchuck, R. F. (1987). *DAN SSSR*, v. 292, p. 73–77.
5. Polishchuk, R. F. (1973). *Vestnik Mosk. universiteta. Fiz., Astron.*, v. 14, N6, p. 710–715.