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COSMOLOGY IN AN INHOMOGENEOUS UNIVERSE

(Abstract for the workshop B2)

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For many years it has been a conventional wisdom in relativity that solutions of Einstein's equations are difficult to find, and so any "new" solution one can derive is valuable. Driven by this idea, most researchers preferred to write papers on exact solutions rather than read them. One of the favorite areas of activity have been inhomogeneous cosmological models. This author has undertaken the task of collecting and classifying all those exact solutions that can reproduce the Robertson-Walker metrics by taking limiting values of parameters or functions, i.e. those that are cosmological models in the most strict sense. The task is not yet completed, but the results are already rather surprising (all the numbers given below are provisional, and will be revised as the work progresses). The total number of papers on the subject is 561, of which 266 contain independent derivations of solutions believed to be new (the other papers discuss properties of the solutions). Of these, only 114 were possibly new at the time when the paper was published, the rest of the 266 were rediscoveries or derivations of special cases. All the 266 solutions can be generated from just 60 by taking limits. Some of the solutions have sources which (according to another conventional wisdom...) are too general for cosmology, like e.g. charged matter or fluid with viscosity or heat conduction. Discarding them, we are left with 188 independently derived perfect fluid and dust solutions that can be generated from only 22 parent solutions.

Most of the work on interpretation was done with the family of solutions that can be generated from Szafron's metric; it includes the solutions of Szekeres (1975) and Lemaitre (1933, the last is known as the "Tolman-Bondi model"). Among the more surprising or exciting results are these (all based on the Lemaitre-Tolman model): 1. The formation and evolution of voids described by exact formulae (worked out by Sato et al. in 1982-83, but investigated qualitatively by Sen already in 1934); 2. The process of forming a black hole in an expanding Universe (Demiański-Lasota 1973); 3. Expansion of planetary orbits caused by cosmological expansion (Gautreau 1984); 4. Spatial variability of the sign of curvature, which implies that the Universe may be expanding in one place and (re-) collapsing elsewhere; 5. Nonsimultaneity of the Big Bang; 6. The existence of naked singularities (Yodzis, Seifert, Müller zum Hagen 1973 + others later). Most startling is the result that an arbitrarily small single electric charge placed anywhere in the Universe can prevent the Big Bang singularity (Shikin 1972 - the conclusion is not explicitly formulated). The same is true if the source is charged dust with the ratio of charge density to matter density sufficiently small everywhere (Ivanenko, Krechet, Lapchinskii 1973, Shikin 1974).

The paper to be published will include both the classification of solutions and a review of their physical properties.