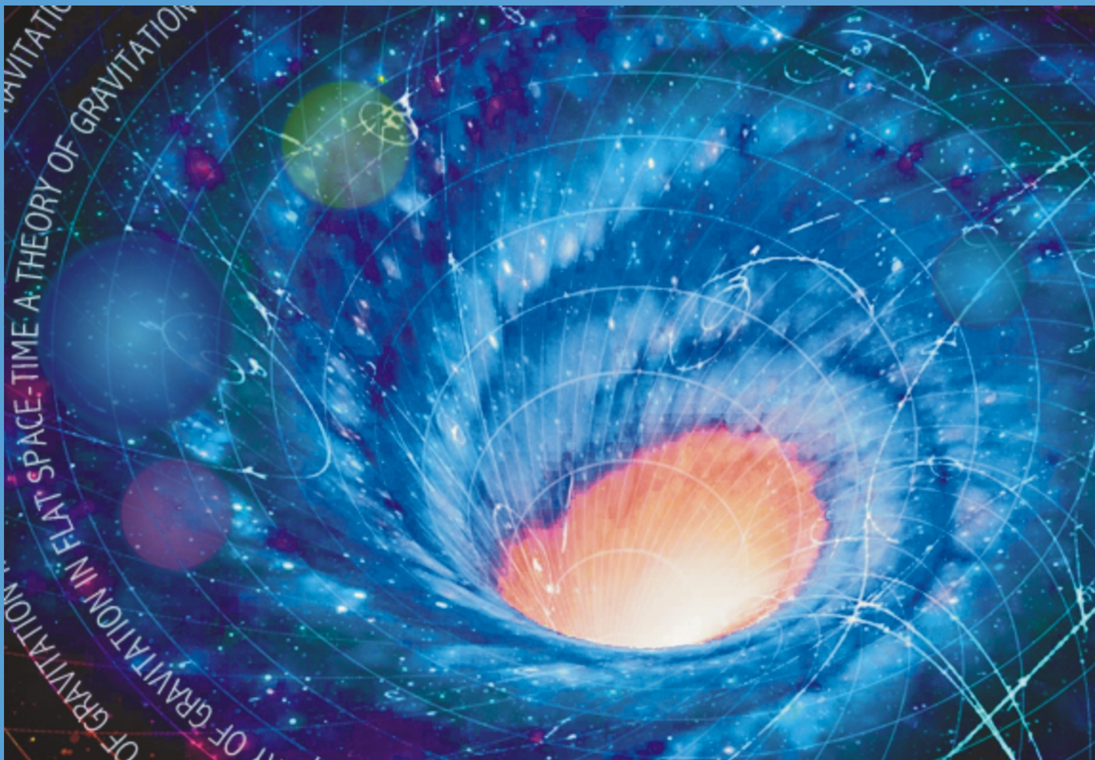

A THEORY OF GRAVITATION IN FLAT SPACE-TIME

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In memory to
Albert Einstein

Dedicated to

My grandchildren

Kira Lucien
Evelyn Maya

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Introduction

Einstein's general theory of relativity is the most accepted theory of gravitation. Gravitation is explained by non-Euclidean geometry and not as field theory as e.g. the theory of Electrodynamics. The great acceptance of general relativity is based on the good predictions of many gravitational effects. The first results given already by Einstein himself are redshift, deflection of light and the perihelion in a static spherically symmetric gravitational field. Later on till now, an extensive study with different applications of general relativity had taken place. Non-stationary solutions of the theory are given, too. In particular, there are the well-known black holes and the expanding universe. In both cases singularities exist; black holes have a singularity in the centre of the body and the universe starts with a singularity in the beginning which is called "big bang". All the standard theories such as e.g. Electrodynamics are field theories whereas Einstein's theory is a geometrical theory. A book about classical field theories is e.g. given by Soper [Sop 76].

Therefore, I start the study of a theory of gravitation. The metric is flat space-time, e.g., the pseudo-Euclidean geometry and the gravitational potentials g_{ij} must satisfy covariant (relative to the metric) differential equations of order two. On the left hand side we have the non-linear differential operator in divergence form of the potentials whereas the total energy-momentum tensor inclusive that of gravitation is the right hand side of the differential equations. It is worth to mention that the energy-momentum of gravitation is a covariant tensor. In addition to the flat space-time metric the proper time τ is defined in analogy to the metric by a quadratic form with the potentials g_{ij} as coefficients. Such theories are already well known and are studied by many authors. They are called bi-metric theories. The first one who has studied such a theory of gravitation was Rosen [Ros 40]. Later on there were given very different bi-metric gravitational theories. Gupta [Gup 54] has the theory of Einstein written in form of a field theory by a successive approximation procedure. Kohler [Koh 52, 53] started from a flat space-time metric with several suitable Lagrangians for the gravitational field similar to our consideration. One of these Lagrangians is identical with our Lagrangian. But Papapetrou et al. [Pap 54] have given an argument against the theory of Kohler showing by linearization of the differential equations that two mass parameters appear in the potentials of the spherically symmetric gravitational field. Kohler [Koh 52, 53] constructed all the Lagrangians which yield a symmetrical energy-momentum tensor. Compare also the later article of Rosen [*Ros* 73] and the extensive study of Logunov and co-workers (see e. g., [*Log* 86]) about bi-metric theories of gravitation.

In this work the theory of gravitation in flat space-time is summarized. It was studied by the author during several years. We do not give other bi-metric theories of gravitation. Many applications of the theory of gravitation in flat space-time are studied and will be given here or at least cited where they can be found. Most of the received results of the theory of gravitation in flat space-time are compared with those of general relativity. We only give a small part of the experimental results. This work is divided into twelve chapters.

The first chapter contains the theory of gravitation in flat space-time. The energy-momentum tensor of the gravitational field is given. The field equations are in covariant form where the left hand side is a differential operator in divergence form of the gravitational field and the right hand side is the whole energy-momentum of matter and gravitation. The conservation of the whole energy-momentum is given. This law together with the field equations implies the equations of motion of matter. The field equations are also rewritten by the use of the field strength of gravitation instead of the gravitational potentials. The angular momentum of a particle and the equations of motion of the spin angular-momentum in the gravitational field are stated. Furthermore, the transformations of the equations of motion and of the spin into a uniformly moving frame are given which is used to study a gyroscope in the gravitational field of a rotating body, e.g. the Earth. This result agrees to the lowest order with the corresponding one of Einstein's theory although the used methods are quite different since gravitation in flat space-time is not a geometrical theory.

In chapter II static, spherically symmetric bodies are studied. The field equations, the equations of motion in this field and the energy-momentum are given. Inertial and gravitational mass are equal. The gravitational field in the exterior of the body is stated. This result agrees with that of Einstein's theory to some accuracy but higher order approximations deviate from one another. The case of non-singular solutions is stated and the equations of motion of a test particle in this field are given. The redshift, the deflection of light and the perihelion shift in a spherically symmetric field are received. They agree to some order with those of general relativity. Furthermore, the radar time delay is given which also agrees to the lowest order with Einstein's theory. Neutron stars are numerically studied.

In chapter III non-stationary, spherically symmetric solutions are stated. The field equations, the equations of motion and the energy-momentum conservation are given without detailed derivations. The differential equations describing the spherically symmetric body are very complicated and cannot be solved analytically; they must be solved numerically. This would be of great interest in the study of black holes.

In chapter IV rotating stars are considered. All the received results are based on numerical computations which are received by some co-workers.

In chapter V post-Newtonian approximations are calculated. The conservation law of the total energy-momentum and the equations of motion are studied. The received results again agree to the lowest order with those of general relativity.

Chapter VI contains the post-Newtonian approximations of spherically symmetry. The 1-post-Newtonian approximation agrees with the one of Einstein's theory but the 2-post-Newtonian approximations do not agree. Flat space-time theory of gravitation doesn't imply the theorem of Birkhoff. The exterior gravitational field of a non-stationary star contains small time-dependent expressions. Furthermore, the motion of a test body in the gravitational field of a non-stationary star is given. The gravitational radiation from binary stars is also studied and it is in agreement with the one of Einstein's theory.

In chapter VII homogeneous, isotropic, cosmological models are studied with and without cosmological constant. The essential result is the existence of non-singular cosmological models, i.e. there exist no "big bang" in contrast to Einstein's theory. Detailed studies of these models are given where analytic solutions can be received under the assumption that there is no cosmic microwave background radiation. In the beginning of the universe no matter exists and all the energy is in form of gravitation. In the course of time matter arises at coasts of gravitational energy. The whole energy is conserved. The universe starts with contraction to a positive value and then it expands for all times. But the two models $\Lambda > 0$ and $\Lambda = 0$ differ from one another. In the first case matter will be slowly destroyed in the course of time whereas in the second case matter in the universe increases for all times to a finite value. In this case the universe is at present time nearly stationary.

In chapter VIII the two possibilities of an expanding and a non-expanding universe are studied. The first interpretation is well known whereas the second interpretation is also possible. The interpretation of the redshift in a non-expanding universe follows by the different kinds of energy, e.g., of matter and of gravitation which are transformed into one another in the universe in the course of time. Therefore, the larger redshift of distant objects is explained by a stronger gravitational field in analogy to the redshift in a static spherically symmetric gravitational field. In addition to the standard proper time, the absolute time is introduced. The age of the universe measured with absolute time is in agreement with experimentally known results even for a vanishing cosmological constant $\Lambda = 0$.

In chapter IX post-Newtonian approximations in the universe are studied where linear, spherically symmetric perturbations are considered. In the beginning of the universe small matter density contrasts arise in the uniform distribution of matter. In the matter dominated universe the density contrast increases very fast in agreement with the observed CMBR anisotropy. General relativity gives only a small increase of the density contrast and has difficulties to explain the observed large scale structures.

In chapter X post-Newtonian approximations in the universe are studied. The gravitational potentials are computed. The equations of motion are given. The gravitational force of long-field force is compared with Newton's force. The radius of compensation of the two forces is computed, i.e., that of Newton's force and that of the long-field force are compared with one another. This radius of compensation of the two forces decreases in a universe with cosmological constant $\Lambda > 0$ and increases in a universe with cosmological constant $\Lambda = 0$.

In chapter XI preferred and non-preferred reference frames are studied. In the preferred frame the pseudo-Euclidean geometry holds and there exists an extensive study of preferred frames in the literature. In the non-preferred reference frame the velocity of light is anisotropic but for the Michelson-Morley experiment and for many other experiments the theory gives the correct results. Transformations from the different frames into one another are studied.

Chapter XII contains some additional results which are not necessary connected with the theory of gravitation in flat space-time. There are essays to explain some experimental results which are received in the last years. The first one is the anomalous flyby where the rotation of the Earth is used to study this effect. It is shown that there is a frequency jump which is not equivalent to a jump of the velocity. In this chapter the equations of Maxwell in a medium are considered, too where in addition to the pseudo-Euclidean geometry the proper-time is introduced in analogy to the theory of gravitation in flat space-time. The well-known equations of Maxwell in a medium are received. This result is subsequently generalized to the equations of Maxwell in a medium contained in the universe. We give an approximate formula for the proper-time of a medium contained in the universe. The arriving frequency of light emitted by an atom from a distant object, as e.g. galaxy or quasar contained in a medium is computed. It is applied to cosmological models. A redshift formula is received under some assumptions. In the special case that the object is not contained in a medium the well-known Hubble law holds. But more generally it may be that the assumption of dark energy is not necessary by the introduction of a medium in which photons are emitted. Galaxies or quasars with nearly the same distances can have quite different redshifts in dependence of different media in which they are contained. Furthermore, the approximate proper-time of a spherically symmetric body is stated where the universe is neglected. The velocity of a test body circulating this body is received. A simple small reflection index which depends on the distance from the centre of the body is studied. It is assumed that the medium has a fixed radius r_0 where the refraction index is equal to one for distances greater than this distance, i.e. there is no medium.

This result is applied to the Pioneers although an anisotropic emission of on-board heat may explain the observed anomalous acceleration. We get also an anomalous acceleration of the Pioneers towards the Sun with a decrease of the acceleration with increasing distance from the Sun. The application of the received velocity of a test body circulating a galaxy can also explain the observed flat rotation curves under some assumptions. The surrounding medium of the galaxy given by the refraction index may be interpreted as dark matter with radius r_0 . In this case, it follows that the mass of this dark matter surrounding the Sun is very small compared to that of the Sun whereas the mass of dark matter surrounding a galaxy is much greater than the mass of the luminous galaxy.

Summarizing it follows that for small gravitational effects the results of flat space-time theory of gravitation and of Einstein's general relativity theory agree to the measured accuracy with one another. But for the case of strong gravitational effects the two theories give quite different results. Here, we will mention the non-singular solutions of cosmological models in flat space-time theory of gravitation which means that the universe does not start with a "big bang" and the theorem of Bikhoff which does not hold in the gravitational theory of flat space-time.

No results are received about collapsing stars. Are they ending in a "black hole" or something else? The describing differential equations of a collapsing star in chapter III are very complicated and may be only solved numerically.

The violation of Bikhoff's theorem gives the hope that the star will not end in a "black hole", that is with a singularity in the centre of the star.

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