“Black Holes” from a Viewpoint of Matter-Antimatter Repulsion

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Abstract

An alternative view of Black-Hole objects is presented which avoids the singular aspect they receive in General Relativity. Purely qualitative argumentation, based on conceivably extremely high temperatures in such high-density objects and the corresponding associated generation of antimatter, leads to the expectation that they are sources of antimatter which is expelled by matter-antimatter repulsion. Positron-electron production at the surface leads to the emission of such pairs at slow velocities which would provide a mechanism for galactic 511-keV radiation. High temperatures at the center of such objects suggests on the one hand a simple mechanism for the observed relativistic jets in “Black-Holes”, with their conspicuous properties. On the other hand, a more isotropic expulsion of antimatter would provide an additional steady generation of antimatter which may give rise to a partial solution of the dark-matter problem.

Introduction

General Relativity (GR) is an extremely successful generalization of Newtons theory of gravitation. However, it has resisted for some eighty years all attempts at providing a working quantized version. Furthermore, because of the extreme weakness of the gravitational force, it has only been possible to verify it to lowest order, 1PN, corrections [1]. For example, perihelion precession is of the order of Schartzschild radius of the central star divided by the orbit radius of the planet, a number less than 10^{-7} for Mercury. There are recent claims of tests in somewhat stronger fields, but those suffer from probably underestimated uncertainties in mass determination [2]. From the very start GR has been used in cosmology to treat situations far away from the linear correction to Newtons theory, namely high-density situations like the “big-bang” theory of an early universe and the ultimate fate of heavy stars in “black holes”. Both situations have thrown up serious questions which float around as unsolved problems in physics [3]. In cosmology it has been recognized that many of it's basic problems would conceivably disappear with the assumption that anti-matter has a negative gravitational mass. Consequently, we looked for, and eventually proposed, a way of setting up quantum field theory such that negative mass, i.e. matter-antimatter repulsion (MAR), is a natural outcome [4]. This setup, which also fulfills a postulate of Dirac and Pauli for a unbounded spectrum of the time translational operator, has additional merits in providing zero energy of the vacuum and free-field propagators with nice convergence behavior.

On the other extreme, black holes as they follow from GR have a very limited set of properties and violate well-established laws of particle physics such as e.g. baryon number conservation. It is clear, that with a description of the gravitational field in a special-relativistic, flat, 4-d world the sequence of star-objects of increasing density will continue beyond neutron stars. This note is intended to give some qualitative ideas about objects which are now just qualified a “black holes” (BH), and we adhere to this name in the extended form of BH-star in order to make clear what observational objects are meant.

Positron-Electron Evaporation

The final fate of stars depends on the amount of mass that comes together. The lightest hurdle is the Chandrasekhar limit (some 1.44 solar masses), determined by the degeneration of electrons. End-states that do not pass this hurdle are called dwarf stars, brown red or white, depending on the intensity with which nuclear fusion takes or took place. Mass aggregation that surpass this hurdle may end up at the next one, the Tolman–Oppenheimer–Volkoff limit (some 3 solar masses), which originates in the idea of a degenerate Fermi-gas of neutrons. This state is a remnant of a catastrophic explosion, a super-nova, during which a sizable amount of the original mass is blown off into space. If the initial mass is high enough, neutron degeneration pressure is not able to stabilize the remnant star and, assuming GR to be valid for that extreme density, the remnant is thought to be a black hole.

However, if theory does not provide such a state, one is led to assume a plasma type state of quarks and gluons that is heated to such an extent that it develops a pressure that can compensate gravitational attraction. This state must be of very small size and have a high gravitational field at the surface such that it can only loose energy at low rate because of the large attraction of matter (red-shift of photons), and it may be quasi-stable if the temperature keeps low enough.

However, if the temperature at the surface rises, at least temporarily, to a level at which positrons can be produced, it is thinkable that positrons are pushed out in space (by MAR). This process would lead to left-back negative charge, such that the BH-star acquires a net negative charge that might eventually compensate for the gravitational force on electrons or positrons. The corresponding charge Q has the value

$$Q = GM \frac{m}{e} \quad ,$$

with G as gravitational constant, M as mass of the BH-star, and electron-mass, m, and -charge e. This charge may possibility be contained in a cloud of electrons surrounding the BH-star. Owing to this charge, any electrons in the outermost regions become loosely bound to the BH-star as well and may evaporate together with positrons. Clearly, any details of such processes depend on the details of the star's state (, something that has not even been considered yet, due to adherence to the dogma of GR-”black holes”). By this mechanism the star can get rid of energy much more efficiently than by radiation of photons.

Owing to the charge acquired by the star due to gravitational emission of positrons gravitational and electric forces will eventually compensate each other, such that positrons as well as electrons will leave the star with relatively low kinetic energy at a rate that is determined by the extent to which the stars temperature allows for positron-electron pair production. Thus, such a BH-star will be surrounded by a cloud of low energy positrons an electrons which will be able to combine to positronium and thus will give rise to 511-keV annihilation radiation. Because we expect BH-stars to be distributed more or less proportional to visible stars in the galaxy (some one in a thousand), this mechanism gives an explanation for the distribution [5] and the spectral properties [6] of the observed galactic 511-keV radiation distribution. Clearly, to obtain absolute intensity values we would need an absolute density as well as a model for such BH-objects, which is far out of the scope of this note.

Jets of BH-stars as Gravity-Caused Ejection of Antimatter

There are rapidly spinning BH-stars with pronounced accretion discs (e.g. core of M87) that show conspicuously sharp jets emitted along the axis of spin. These jets are highly relativistic and it is not clear how to explain this within the concepts of GR (not yet fully understood in expert terms). The problem is to explain how matter could possibly be accelerated to such an extent that it still emanates at relativistic speed, in-spite of being held back by the extreme attraction of a super-massive BH-star or even by the attraction of the whole galaxy as in the case of M87. Furthermore, it does not seem obvious how the extreme sharpness of the jet should come about. However, with MAR it appears much more obvious, that those astonishing properties could occur, at least if one could think up a mechanism by which anti-matter 'bubbles' could be ejected by the BH-star. Clearly such bubbles would leave the star in a straight jet an would be accelerated to escape-velocity of the star which is practically the speed of light for a massive BH-star. The collimation to a narrow jet can also be accounted for quite plausibly, because such jets seem to be associated with high-spin BH-stars, in which the poles are special points by symmetry.

Thus, how could antimatter possibly be generated in such a star. Not having anything like an equation of state (not assuming GR to hold) for this dense and hot matter, one may proceed by analogy and assume that the temperature at the center exceeds the surface temperature by a factor of some 1000, as e.g. in the sun. This may at least hold in initial stages, e.g. after energy take-up (mass in-fall from an accretion disk), until cooling mechanisms may establish a more equalized temperature distribution. With positron-electron pair production taking place at the surface, this factor would bring up the center-temperature into a range where baryonic antimatter can be generated. Due to MAR something like phase-separation may then take place leading to a boiling process in the star's center. In addition, MAR would cause off-center buoyancy and drive bubbles towards the stars surface. However, because the temperature decreases towards the surface the bubbles will shrink on their way like steam bubbles in a pan of water heated from below in which the surface temperature has not yet reached the boiling point. Nevertheless, it is not inconceivable that the first points where bubbles could reach the surface are the poles, because on the one hand the star may be flattened by rotation, yielding the shortest path to the surface in direction towards the poles. On the other hand, differential rotation towards the equator may distort and disrupt the bubbles which would favor annihilation due to increased bubble surface.

Along such lines, MAR could provide a simple explanation for the conspicuously sharp an long jets in active galactic nuclei and other BH-objects. Clearly, the reasoning is extremely speculative in what regards the actual processes, but whatever the details may turn out to be, the basic idea, that MAR can account for jets with their conspicuous properties by a process of ejection of antimatter, is a simple and attractive idea. Jets are an extreme form in apparently violently rotating systems, but one could imagine that the same type of process may take place in slower spinning stars which would then yield a more isotropically distributed ejection of antimatter.

Clearly, such a mechanism would also provide a route for additional acquisition of mass of a BH-star, because for each ejected bubble of anti-matter the equivalent amount of matter must be left back in the star. This extra mass will also help to take up angular momentum.

Furthermore, this mechanism implies that within and around a galaxy there will be some density of antimatter, flowing away from the galaxy. The value of this density depends on the importance of the anti-matter expulsion process by BH-objects. Whether it will be large enough to provide a contribution to the dark-matter problem with its additional centripetal force to the galaxy's matter, must await a theoretical treatment of BH-stars in the future. It may also be mentioned, that such a negative-mass density would provide a basis for the gravitational anti-shielding process [7], that could rationalize the proposed model of Modified Newtonian Dynamics (MOND), which in turn gives a very convincing phenomenological explanation to accelerated galaxy rotations and galaxy-cluster dynamics [8,9].

Implications for a MAR Cosmos

A MAR-Cosmos is a more or less homogeneous distribution of interpenetrating galaxy clusters which are in a continuous process of coagulation of equal types of matter, and separation of opposite types. Since BH-objects occur at the level of one in a thousand stars and the occurrence of a super-massive BH seem to be the rule in the center of most galaxies, the above considerations suggest, that a steady generation of opposite-type matter takes place as a rule. This is reminiscent to some extent of the steady-state theory of Hoyle, Bondi, and Gold [10,11].

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