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MEASURING GRAVITY IN THE VICINITY OF THE EARTH
spectral analysis and related modular structures after further experimental devices

OBJECTIVES

The General Relativity effects of a particle and/or an experimental device close to the Earth (magnetic field), responsible for the gyromagnetic effect, can be distinguished by those of those generated by the detectable contributions deriving from a most general setting of a test particle orbiting a non symmetric Kerr-Newman black hole. They can be analyzed at 2.5 Post-Newtonian parameterized formalisms compared (after BirkhoffâĂŹs theorem of asymptotic flatness), by the suitable spectral analysis.

1. Quantum implementation
2. Quantum semiclassical wavefunctions
3. Gravitomagnetic contributions form the pertinent celestial body
4. Gravitational contributions from the 'faraway'.
5. Bounds on non Riemannian contributions, non geometrical implementations, and non-gravitational Physics.
6. Spectral analysis

MATERIALS & METHODS

•The corrections to the wavefunction of a particles can therefore be applied both to the energy levels, and to the phase, respectively:
O(c^{-6}) and O($\hbar^{-2}$) to keep the corrections not summed; differently, the spectral analysis
$\Delta E=\sum_n a_{0n}\frac{a_n}{\hbar}\frac{d^n f_\rho}{dm_\rho{}^n}+\sum_n b_{0n}\frac{b_n}{L_p}\frac{d^n f_\rho}{dp_\rho{}^n}$ (2)
reveals and constrains the a_n terms as referring to the non-relativistic or geometrical corrections, while the b_n terms to the relativistic-particles (of 4-moment p) ones to keep Wigner-Bargmann theorem hold, i.e. to ensure Poincaré particles, and/or particle suited for 'bigger' groups (so-called *small groups*.

• The mathematical implication of such semiclassicalization techniques is the deformation theory induced in quantum mechanics.
It is possible that the consideration of all the possible contributions to the quantum gravitomagnetic system does not imply a codified (quantum) Haar measure; possibly, some subgroups of the extended modular group are not sufficient to recover the complete support of the quantum system(s) obtained. For this, it is possible to pick up the related modular structures, and match them in the subregions of the (phase space component of the position(s)).

• Birkhoff's theorem of asymptotic flatness ensures that, asymptotically, the effects analyzed will not affect any experiments on phenomena happening at ∞.
Nevertheless, for this, there is a host of other contributions, which are supposed to be detected at largest (but still finite) distances on Earth experiments. The modifications of the eigenvalues of the quantum-mechanical implementation of $\Psi^{F2}_{3.5PN}$ and (1b) can be estimated to be at most the same order in c as $\Psi^{F2}_{3.5PN}$, if without other experimental detection, taking for granted that any modification of General Relativity at large but finite distances does not modify the celestial objects and/or the observed phenomena, from which the different components of the spectral analysis are hypothesizes as descending from and therefore scanned accordingly in the spectral analysis.
•The exact asymptotic expressions for the Teukolsky eq.for circular orbit test particles within the Penrose formalism has been completed in with the corresponding weighted spin harmonics, and the effective potential experimented by the test particle according to the same decomposition.
•The result holds both for the odd-parity perturbations of the background metric tensor, while the even-parity perturbations do not need such specification; and also for any other several arbitrary functions of the remaining variables (t,r) needed in the definitions.
The relevant terms in non-spherical perturbations on a Schwarzschild background can be demonstrated of finite number by comparing the pattern functions to the solution to the Teukolsky eq by Newmann-Penrose formalism and the weighted-spin-harmonics expressions, for which the components of the spintensor define the components of the spin vector together with the velocities v^μ of a test particle.

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INTRODUCTION

The quantum-mechanical implementation of the gravitomagnetic Hamiltonian requires the wavefunctions
$\Psi_\pm(t,\beta)=Ae^{-i\beta}e^{-\frac{i}{\hbar}E_\pm t}$ (1a)
invariant as
$\Psi(t,\beta)=\Psi(t+T_\pm,\beta+2\pi)$, $E_\pm=\pm\frac{2\pi\hbar}{T_\pm}$, $T_+-T_-=4\pi a$ (1b).
Any corrections to the energy levels must be at least one order greater than those to the phase.
• $\Delta E\simeq a_0\frac{R_q mc}{\hbar}\Omega$ $\Omega\simeq\frac{R_S R_b^2}{r^3}\omega$
Earth systems (ES) $\Omega_{ES}\simeq 10^{-13}rad/s$ and rapidly -spinning neutron star (NS): $\Omega_{NS}\simeq 10^{-13}rad/s$
R_q being the dimension of the experimental setting lengths (on the celestial body or its vicinity), R_S the Schwarzschild radius, R_S the radius, r the distance at which the measurement is performed;
• maximal rotation rate of a strange star $_K=(3.234G\rho_0)^{1/2}$, with ρ the macroscopic (dust) matter density in the Einstein field equations.
The correction terms for the energy levels must be O($\hbar^{-2}$), in absence of other contributions, can depend on the velocity $\tilde v$ of the test mass O($(\frac{\tilde v}{c})^5$)$\sim$ Oc^{-5}, wrt GR orders; those for the phase β, Oc^{-6} and O($\hbar^{-3}$). Other contributions are here evaluated, and the components of the spectrum constrained to that of a Wigner-Bargmann particle.

RESULTS 2

• For spinning test particles in a Kerr metric, the two possible directions for the test masses allow for the equalities for the coordinate time and for the proper time, resp.,
$t_\pm=T_K(1\pm\frac{a\omega_K}{c})$,
$\tau_\pm=T_K\left(1\pm 2\frac{a\omega_K}{c}-\frac{3}{2}\frac{R_g}{r}\right)^{1/2}$,
which contain the Kerr parameter a, the gravitomagnetic potentials, the $\tau_\pm$ depend on the gravitational radius of the source R_g, i.e. after bein projection of the Ricci tensor at O(c^{-4}).

Teleparallel models of gravity, whose action which can contain the tetrad projection of the teleparallel curvature (rank4-) tensor or the Torsion field strength(s) either at the manner of identifying traslations or of considering the rotational field strength of the tetrad also in the stationary case, imply corrections to the tetrad projections of the Ricci tensor containing suitable combinations of the non-Riemannian objects, are direction-dependent, which must be requested to be at most O(c^{-4}) to start overlapping even with the Schwarzschild solution.

For the case of beams of particles in straight-line motion, the same effect can be described by a time-varying rotating frame; also for semiconductors in Einsteinian gravity: considering the Earth precession variation must imply corrections at least of $O(10^{-8})s$.

• the order of the solutions is given by
$\tau_++\tau_-\simeq 2T_K+\mathcal{O}(c^{-2})$
$\tau_+-\tau_-=4\pi\frac{J}{Mc^2}\left[1+\left(\frac{3}{2}J_2-\frac{9}{2}K_2\right)\frac{\rho}{\rho_e}\right]$;
for the Earth $J_2\simeq K_2\simeq -10^{-3}$, the angular momentum of the Earth ($a\simeq 3m$);
$\Delta\tau\simeq 10^{-7}s$.
• for spinning test particles in the Kerr metric, the difference $t+-t-$ has been evaluated numerically by integrating the two directions of motion successively, and then by applying a Runge Gutta methods for the differential equations, as $t_+-t_-=2.521207903510-8s$.
• The preferred (i.e. CMB) direction of the observable universe can also be interpreted as for one of different regions (not observed yet) have different such features, which induce spontaneous polarization(s) in fundamental laws,also in electromagnetic propagation, and the possibility to have super-weak long-(r)range spin-spin two- particles interaction with interaction potential
$V_{S_1S_2}=-\frac{\tilde g^2}{2r})\left[\vec S_1\cdot\vec S_2+\frac{(\vec S_1\cdot\vec r)(\vec S_2\cdot\vec r)}{r^2}\right]$;
• For the analysis of cosmic anisotropy for electrons, a spin interaction Hamiltonian H_C
$H_C=H_C(C_1\neq C_2\neq C_3;\vec\sigma)\equiv C_1\sigma_1+C_2\sigma_2+C_3\sigma_3$
, constrains $(C_1^2+C_2^2)^{1/2}<3\cdot 10^{-20}\ eV$ and $C_3<7\cdot 10^{-19}\ eV$ by requiring agreement between spin-spin interaction consistency within the preferred reference frame.

FUTURE RESEARCH

The modifications to the spectrum can be controlled by different experimental devices and settings, such as on th Earth or on the vicinity of the Earth.
The developments of technical improvements of experimental settings, such as satellites, detectors and interferometers, as well as the appropriate application of computer-based techniques and for the electrically-converted signal to be analyzed.
The spectral analysis reveals at the requested order the two different contributions: the possible outreaches of other theories of gravitations, which include Einsteinian gravity as a low-energy limit, and/or, as a proper geometric limit, can also be scanned, according to the different contributions in the detected (suitably reconstructed) spectrum.
It is possible to choose the related modular structures, and match them in the subregions of the (phase space component of the position(s)) coordinate representation(s), where, at least, more than one structure of the extended modular group is needed to reconduct to the invariances induced by the different regions outlined by the (contiguous) semiclassicalization techniques at different space/time interval-delimited regions identified in this manner.

RESULTS 1

From black holes in an inspiralling compact binary system, correction terms available at Earth (vicinity) are the long range effects $\Psi^{F2}_{3.5PN}=...+\Psi^{F2}_\infty$ (10)
$\Psi^{F2}_\infty\equiv\Psi^{F2}_\infty(v;m,\nu,\xi_i)$.
$F2_\infty$ takes into account non-spinning, spin-orbit, quadratic-in-spin, the cubic-in-spin contributions but not the black-hole absorption of the horizon fluxes;
PN energy flux F_∞ available reaching still at infinity is $F_\infty\simeq\frac{32}{5}\nu^2v^{10}\mathcal{O}(v^8)$: with numerical calculations comparable with a Kerr geometry at 3.5PN order.

Azimuthal perturbations of bh's produce quasi-periodic oscillations, which stay stable wrt successive perturbations, and induce accretion matter for the black hole in a quasi-periodic oscillating-in frequency manner, differently wrt the bh geometry and bh matter distribution than the equatorial horizon flux absorption $F2_\infty$, but does not modify the bh nature: its $\Psi^{F2'}_\infty$ can compare at most O(v^8) with higher-order corrections of O(v^9) at 3.5PN order, $\Psi^{F2}_{az}{}_\infty(\nu')$, with $\nu'\neq\nu$.

Inverse control: $F_\infty(\nu')$ must be absent in the cubic-in-spin ($_{CC}$) compact-object binaries calculations at leading PN order for circular -orbit description of spin-aligned at $3-2$ PN order up to Oc^{-4}; any different $F^{CC}_\infty(\tilde\nu_{CC})$ can be at most starting from O((c^{-5})); $F_\infty(\tilde\nu)$ from quadratic in- spin contributions at 3PN order, the cubic-in-spin terms 3.5PN order, and, and the spin-orbit coupling at 4PN order; for non-precessing inspiralling binaries, *by using generic spins* $_{gs}$, spin contributions $_{gs}$ in the frequency domain and in the phase domain at 2PN order addends have been found estimated as O(c^{-5}), such that any $F^{gs}_\infty(\widehat\nu_{gs})$ must be looked for at least as O(c^{-6})

CONCLUSION

•An expansion of the metric resulting from non-spherical perturbations of a spherical Schwarzschild background, it is possible to remark that for the case of a spinning test particle interacting with a spherically-symmetric background metric with total angular momentum in the x^3 direction [**?**], the symmetries of the problem allow one to project the infinite l sum to a finite sum of associated Legendre polynomials.
The components of the spin tensor (**??**) can also be rewritten in terms of the angular pattern functions: the decomposition in terms of Legendre polynomials, or in terms of associated Legendre polynomials, is straightforward in outlining the projection mechanism, according to which no complex phase is needed. In particular, only the functions $W^{l,m=0}$ are needed.
Any composition of the other angular pattern functions such that the complex phase is cancelled can be used: the number of non-vanishing contributions is therefore finite.
Numerical simulation for a particle orbiting a Kerr black hole has been thoroughly exploited, of which only the Ψ^{F2}_∞ addend is expected to modify the gravitomagnetic Hamiltonian for lab(oratory systems) in the Earth or on satellite(s) in the vicinity of the Earth.

The double control of the spectral analysis (2) allows one to define the availability rate of a spectral term for the description of a searched phenomenon (with respect to the Einsteinian gravity and to the Poincaré invariance for particle physics, as well as the proper cosmological implementation.
The spectral analysis allows to discern from modified theories of gravity, also within the most general reformulation, due to a different order of the fundamental constants in the spectral decomposition, possible non-metric contributions and/or non-geometric ones, for variation of fundamental constants also of non-gravitational-Physics origin.

The possible results of other theories implying (also) gravitations, which include Einsteinian gravity as a low-energy limit, can also be sampled in the spectrum, according to the different contributions in the detected (suitably reconstructed) spectrum, form which it is also, especially, possible to discern from the contributions of cosmological origins from those due to the Earth gravitomagnetic moment coupling(s).
A comparison among the addends of the spectra of the geometric addends wrt those resulting from relativistic wavefunctions for particles defines the possible regions of the spectrum parameter space for the detections of the investigated phenomena, under the constraint of the observational data and the phenomenological analysis.

- Variation of the (fundamental) cosmological constant wrt time, $\dot G$: from term $_1$geometrical correction of a as $(L_P^2/(G\hbar)^{1/3})a_1$ from (5) constraining α_0 and β_0 and by keeping ϕ_{*0} fixed;
  the remaining parameter range available to determine the dynamics of ϕ_{*0} from b_1.
- quadrupole moment Φ_2 parameter for a gravitational mass $\bar M$ has the same functional expression (also as a function of the Kerr rotation parameter $\tilde j$) both for circular orbits and (slightly-perturbed) non-circular ones: possible to discriminate between two Kerr black holes or two Kerr disks from the $_1$ a term, as $L_P/(c\hbar G)a_1$, as $\Phi_2\sim c^{-4}$ in the static limit (by neglecting the secular mass $\bar M$ change).
- a_1 must contain also the most stringent constraints on the anisotropies in the electron spin (i.e. also those arising from cosmological origin); in vacuum, a large part for the contributions to a_1 can still be available; in presence of matter, the constrains (8) are very close to the definition of a Planck mass M_P, s.t. the difference is at most O$h^(-1)$ for a_2 or the next-order terms; a remaining addend defining b_1 must also ensure Wigner-Barman features for particles, the discrepancy from them being given by $b1/(C_1^2+C_2^2)^{1/2}$ and b_1/C_3+ O(L_P^{-2}) in the b_i's, $_i\geq 2$: the order of the discrepancy can therefore be looked for at b_4 for the conservation of the momentum.
- small charged superconductor experimenting gravitomagnetic effect, the possible non-Riemannian contribution contained in as $(Z_0/(\Omega-Z_0))$ in a_{0n}; it can corresponds to the possible contributions due to teleparallel gravity within the $\hbar\ a_n$ terms at O(c^{-4}) to compare at least with a Schwarzschild solution in presence of a test particle of negligible mass: for a massive particle, starting from Oc^{-2} in the b_i, the same order in the time corrections (1) and (2) at 3-5PPN, i.e. for which $(L_P^2/(c\hbar))^{2/3}b_2$.

The weak-field limit of GR on the Earth for a $\bar v$ moving charged mass can produce gravitomagnetic corrections $\bar c_{Bg}$ to the $\alpha 1\beta 2$ bein projections of the Ricci tensor as $\bar c_{Bg}\leq\bar vgc^{-2}$ in the case of a test mass (for which the tetradic projection is proportional to a δ projection O(c^{-3})), and $c_{Bg}\leq$ O $\bar vgc^{-2}$ in the case of a massive particle.

• The effects of imposing $Q=0$ for Kerr-Newmann spacetimes have been proven not to be defining for non-charged test particles, as, from neutron experiment, they have been observed t be distinguishable (on the two arms of an interferometer), as labelled by internal states, i.e. by the different harmonic(s) expansion (of their deBroglie lengths) generated by their energy-momenta.

• The precisions at which arcosecond errors in position in modern astrophysical position observation for contributions associated to (also, outside) Solar system sources can be compared only at 1PN, and 2PN order for precision required about light deflection by the Sun, due to the difference of velocities at which the Sun and the extra-Solar-System sources. It is possible to improve the accuracy of the numerical simulation(s) by calculating the remainder of star position parallaxes expansions. The correlation in the measurements acquires efficiency by being enhanced by both the brightness of the considered celestial bodies and the distance distributions.
For this, the evaluation of the remainder on the second PN formalism for the motion for the (Earth) moon has been calculated not t produce any such detectable effect either on Earth-based experiments or on Earth satellite ones.

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