On Kip Thorne's limit for rotation of black holes

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Summary

In 1974 Kip Thorne showed that the maximum rotation of black holes cannot reach the value of M, where M means the mass of the rotational black hole of irreducible mass M_{irr} and including the mass equivalent of rotational energy. Using simulation calculations he showed that this limit should be near 0.998*M. Much work was done since then to evaluate this limit more precisely. *The purpose of this paper is to derive the limit by simple calculation*.

The base for this calculation is a formula for Kerr-Newman black holes[1] and (in the background) the idea that our universe does not contain any matter at all but just is curved spacetime. Objects are black holes and collections of those. This has of course the consequence, that elementary particles should be kind of black holes too. See my project agenda. Note also, that *black hole* in this context is not restricted to gravity, but is extreme curved spacetime structure.

One another consequence will be the time dependency of the Lorentz factor. For the special case of a radial velocity field describing the expansion of our universe we can show that dark matter may be explained by the radial acceleration that must be added to every rotational system, i.e. galaxies or clusters, thus leading to a precision of MOND theory.

1 which yields a Kip-Thorne-limit of 0.998_{172}

Kip Thorne's limit

We are using Planck units in the calculations to come.

Remember the Kerr-Newman-identity for rotational, charged black holes:

$M^2 = \frac{(4M_{irr}^2+Q^2)^2}{4(4M_{irr}^2-a^2)}$ **(Kerr-Newman)**

where M_{irr} denotes the irreducible mass, Q the charge, a the spin factor and M the mass M_{irr} including the mass equivalent to rotation and charge energy[2]. And all items have unit Planck length l_p.

For Q=0 one gets the Kerr identity for rotating black holes $M^2 = \frac{4M_{irr}^4}{4M_{irr}^2-a^2}$ **(Kerr)**

So together (a' instead of a in the Kerr-identity):

(K) $M^2 = \frac{4M_{irr}^4}{4M_{irr}^2-a'^2} = \frac{(4M_{irr}^2+Q^2)^2}{4(4M_{irr}^2-a^2)}$ **(KN)**

In the case of maximal spin factor $a'^2 = M^2$ for the Kerr case (K) we get: $M^2 = 2M_{irr}^2$ and thus for (KN) after short calculation:

$a^2 = M^2 - Q^2\left(1+\frac{Q^2}{8M_{irr}^2}\right) = M^2 - Q^2\left(1+\frac{Q^2}{4M^2}\right)$

$\rightarrow a = \pm M^* \sqrt{1-\frac{Q^2}{M^2}\left(1+\frac{Q^2}{4M^2}\right)}$

Setting $M_{irr}^2 = 1$ (smallest value in units of l_p^2), thus $M^2 = 2$ and $Q^2=\alpha$ (fine structure constant):

$a = \pm\sqrt{1-\frac{\alpha}{2}\left(1+\frac{\alpha}{8}\right)} * M = \pm 0{,}998_{172} * M$ (at M=2). But since (K) and (KN) are homogeneous, we get for arbitrary natural number n:

$nM^2 = \frac{(4nM_{irr}^2+n\alpha)^2}{4(4nM_{irr}^2-na^2)}$, therefore: $na^2 = nM^2 - nQ^2\left(1+\frac{nQ^2}{4nM^2}\right) = nM^2(1-\frac{Q^2}{M^2}\left(1+\frac{Q^2}{4M^2}\right))$, so Kip Thorne's limit also for big black holes.

Conclusion

It is already well-known, that the fine structure constant is not a constant at all. It is energy dependent, as experiments on the LHC showed. So, α increases, when we are approaching the Big Bang. This means, of course, that Kip Thorne's limit is a function of the age of our universe. I would expect, that it hardly changes, when we go back in time till CMB. At CMB things will change, meaning that α will increase significantly, and so Kip Thorne's limit will get smaller. Passing CMB in direction to the Big Bang, black holes will change more and more from Kerr-Newman-type to Reissner-type (charged, non-rotating black hole)

So, when the fine structure constant α is a function of time, do there exist minimal and maximal values?

[2] Note, that the term mass and charge associated with M and Q is somehow misleading, since in fact we can only compare spins M^2 and Q^2. In this context, M^2 and Q^2 denote spins, that we associate with certain phenomena called gravitation and electromagnetism.

One easily recognizes that α cannot grow beyond $4 * (\sqrt{2} - 1)$ [3]. And for α=$4 * (\sqrt{2} - 1)$ we get a^2=0. On the other hand, we have α > 0, because for α = 0 we would get a spin factor a^2 = M. Therefore, we end up with:

$4 * (\sqrt{2} - 1)$ ≥ α=α(t) > 0 , as time evolves.

Falsification

More precise simulation calculations.

References

Nothing special

[3] Note, that this is an upper limit, due to the Kerr-Newman-identity.