THE POSITIVE ENERGY CONDITIONS IN A NEAR BLACK HOLE

G.N.N.MARTIN

Abstract. I speculate that the positive energy conditions are maintained by quantum events, in which case I suggest it is unlikely they can be relied on in the extreme conditions associated with a black hole.

1. The maintenance of the energy conditions

I assume the energy conditions are not a direct consequence of the Bianchi identities, because I expect that if they were someone would have shown that to be so, and they would be assertions rather than assumptions. Furthermore, the energy conditions are inferences drawn from observations of the physics of observables, hence from the observation of quantum events.

2. Black holes and the coordinate system

Friedmann's equations assume that the universe can be described as a homogenous and isotropic space which may be expanding or contracting with time. With these assumptions we can describe the whole of space/time with a single coordinate system, $\{t, x, y, z\}$ say. Space is, of course, not perfectly homogenous. A Friedmann based coordinate system typically ignores the inhomogeneities. I wish to include them, and particularly to include collapsing stars.

The inhomogeneities mean that the scale of the coordinate system varies from point to point. The metric tells us the scale at each point. I choose the overall scale of the coordinates so that on earth the scale is approximately one to one, a coordinate metre maps a physical metre and a local second lasts for a coordinate second. The scale at any point can then be described by saying how many coordinate seconds (or metres) represent one local second (or metre) at that point.

On the surface of a star local time runs slow: a local second will last longer than a coordinate second. As the star collapses, local time runs ever slower, though it never quite stops in the chosen coordinate system[1]. None the less I shall call such collapsing stars 'black holes', because that is the term in general use: just remember that these 'black holes' are not yet totally black!

A metric for a Kerr (rotating) black hole describes space as being 'dragged along' by the star, so the metric does not just tell us the scale of time and space, it also tells

[1]Oppenheimer & Snyder described the collapse of a star in 1939 and showed that in a stationary coordinate system the local time at the surface of the star slows as it approaches what is usually described as a black hole, so the black hole does not actually form as long as the stationary coordinate system remains a realistic description of space/time. The coordinate system chosen in this paper is not quite stationary, but I believe and assume that collapsing stars will not quite form a black hole as long as the coordinate system is realistic.

us how fast space is moving relative to the coordinates. When a black hole is moving relative to the coordinates, it is the space that is moving. By contrast, the movement *in space* of particles close to a black hole is insignificant because the local time is so slowed.

A paper[2] describes the merger of two black holes. Two intrinsic spheres each about 650 Km in circumference orbit each other a few times and then merge to form a single sphere in about 0.25 seconds of coordinate time. The contents of the spheres mix, and the mixing is surely turbulent, but it is the space that is mixing and the space that is turbulent. The merger might take as little as a millisecond of local time at the surface of the stars, even less at the centres: there is no time for significant movement in space.

3. Extreme conditions

If far from any black holes two fluid spheres collided and merged, the motions of the fluid would be turbulent. When two black holes collide and merge, I expect that the movement of space relative to the coordinates will be similarly turbulent. When two black holes merge, then the exterior of the resulting black hole quickly becomes axially symmetric (or spherically symmetric if the result is not spinning). This might suggest that the space internal to the hole quickly becomes less turbulent, but why should it? Without movement *in* space, there is no mechanism to damp the movement *of* space. I assume that non-local quantised action is responsible for the relaxation of the turbulence of space, and quantised action slows with local time.

In such conditions there is no obvious reason why the energy conditions continue to be realistic.

4. Conclusion

Roger Penrose and Stephen Hawking together concluded that if the energy conditions were realistic then matter would collapse to a singularity at the centre of a black hole. I hope I have cast doubt on the assumed energy conditions.

[2] `https://arxiv.org/pdf/1602.03837.pdf`: Observation of Gravitational Waves from a Binary Black Hole Merger.