PROCEEDINGS OF SCIENCE

Gravitational Astrophysics

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In this talk, I maintain that many published statements of modern astrophysics are inconsistent, and even wrong. In summary, I will (try to) prove the following 4 claims: 1) There are no black holes (BHs) in our Universe, neither of stellar mass, nor supermassive ones (SMBHs), nor of any other mass. 2) The gravitational-wave signals (GWs) detected since 2015 were all emitted by fusing binary neutron stars. 3) Almost all 'loud' received electromagnetic signals were emitted by nearby (Galactic) sources, not by sources at cosmological distances; such as the gamma-ray bursts (GRBs), and the fast radio bursts (FRBs). An exception to 'nearby loud GRBs' is the short γ-ray signal of GW170817, with its (large) emission distance of 40 Mpc, and its gigantic formation energy (of 2 merging neutron stars). 4) Astrophysics deals with 'inorganic machines'; it is often not easy to model these machines correctly.

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1. Introduction

In this presentation, I will argue that our understanding of the Universe, based on observations with ever improving spatial and spectral resolution, can be consistently described by regular solutions of Einstein's GRT, without singularities – such as BHs, or naked singularities (NSs) – and without phenomena that would violate the fundamental conservation laws of 4-momentum, or growth of entropy. We have all been hasty when 'concluding' that singularities could form in the Universe under certain extreme conditions, or when allowing for super-energetic happenings. Such worries arose at the very beginning of a new era of increased technical facilities, and should now be reconsidered with greater patience.

2. Reasons for, and against the occurrence of BHs in our cosmic neighbourhood

a) Why should we expect to encounter BHs anywhere in the Universe? Most of us have learned that BHs form an unavoidable last step in the compression of matter. Stars are stabilised by internal pressures exerted by the hot, nuclear-burning plasma in their interiors; planets and moons are stabilised by liquid- and solid-state forces, white dwarfs (of mass below 1.4 $M_\odot$) by electron-degeneracy pressure, and neutron stars – their decay product, when overloaden, though still of mass below some 3 $M_\odot$ – essentially by the Fermi pressure of free neutrons, combined with nuclear repulsive forces. But then, so we learned, if a neutron star is loaden with additional mass, beyond a total of some 3 $M_\odot$, it will get hopelessly unstable, and collapse under its own weight, to the unstable state of an ever shrinking black hole, without a stable surface, or interior; because according to GR, even pressure has weight, and eventually weighs heavier than what it can support.

But so far, all observed neutron stars have masses below some 2 $M_\odot$ [Antoniadis et al, 2016], and all binary neutron stars are observed not to spin up secularly – via accretion – i.e. to get 'recycled', rather to oscillate in spin period around some quasi-stable spin value throughout cosmic times, at oscillation periods of $\gtrsim$ ten years. And even if there existed a binary neutron star somewhere in our Galaxy, or Universe, whose companion dropped large amounts of matter onto it, such accreted matter would reach its surface at an infall velocity of almost the speed of light, and try to 'recycle' it, not to crush it out of existence. No BH would form. Neutron stars are stable objects. No wonder that even now, some 50 years after their baptism, no BH has been reliably detected in the sky.

b) What have been the evidences? The international discussion on BHs started for me at Varenna in the summer of 1972, with Cyg X-1, a bright, massive star with an unseen massive binary companion. A few years later, in [Kundt, 1979], I concluded that the unseen, massive companion was a neutron star surrounded by a massive accretion disk, kindly refereed by Ed van den Heuvel and Jerry Ostriker. Some further 10 years later, Daniel Fischer and I concluded that all the (then 26) known Galactic stellar-mass BH candidates (BHCs) could be well described by neutron stars inside of massive accretion disks, [Kundt & Fischer, 1989; Kundt, 1998].

And why should (many of) the hot, luminous central sources of massive galaxies be supermassive black holes (SMBHs), as has been pushed, in particular, by Donald Lynden-Bell? To me, the AGN look like the largest nuclear reactors in the Universe, fed by the inspiralling matter of their disk, whereby in the case of our own Galaxy, $\dot{M}_{in} = \dot{M}_{out}$ had been measured early on by Suzy Collin, suggesting complete re-ejection of the infalling matter from near the bottom of its (Galactic) potential well [Collin-Souffrin, 1993, Kundt, 1996, 2013]. This interpretation has been strongly supported by the SDSS plot, according to which the core masses of all sampled galaxies decrease statistically, from some $10^{10}M_\odot$, near z = 5, to some $10^6M_\odot$ at present, during cosmic expansion [Kormendy & Bender, 2011]. (BHs would grow with time, instead). My most recent understanding of the functioning of our Galactic core – SgrA* – has appeared in [Kundt, 2017a]. It is not all that well described in the literature because its optical radiation is reduced by some 31 magnitudes of absorption by foreground dust, and because its radiation reaches us strongly weakened by having climbed out of the deepest potential well in our galaxy. It extends from low radio frequencies up to hard γ-rays – of order PeV – through 18 orders of magnitude in frequency, and is time-variable on all scales down to 0.1 minute. I like to call it a burning disk (BD), being the nuclear-burning innermost part of our Milky-Way disk. Its radius measures no more than 10^{14}cm = 10 AU. Apparently, its burning is extremely unstable, like that of a 2-dimensional star [Roxburgh, 1993], unique inside our Galaxy. In my understanding, no BH hides anywhere near Sgr A*.

c) A property of Hawking's BHs that has been overlooked for some 50 years is their unsteady behaviour: they swallow everything they can get hold of, radiation, stellar winds, flows, stars, star clusters, galaxies; they are not stationary objects. It's a chaotic process, not obeying any analytical law; but their growth reaches even galactic scales on interesting time scales, like 10^8yr, at the high-mass end. The larger their mass, the faster they accrete, simply via gravitational attraction. Had there been SMBHs around already at large redshifts, in our Galaxy and in neighbouring ones – and the SDSS plot has shown such high masses – all of us would now be inside of them. We owe our existence to their absence.

3. Gravitational Waves reach us from merging binary neutron stars

In section 2 we have noticed that our human existence is inconsistent with the presence of BHs around us. How then could Advanced LIGO detect some six of them, during the past three years, even a lot more massive than our Sun? Are gravitational waves magic detectors? Or has the evaluation of those 6 detections gone astray? Have two Nobel prizes been issued with faulty justifications? (As has happened before). I vote against the BHs.

For me, since 1974, it has been a safe expectation that at some time in the future – once we have managed to build sufficiently sensitive detectors – physicists will be able to witness the fusion of two neutron stars, among them the Hulse-Taylor Binary Pulsar – detected as PSR 1913+16 – via their gigantic gravitational shatter. No other celestial phenomenon we could think of was powerful enough to compete in strength: solar masses approaching each other at almost the speed of light! On the other hand, even decades later, none of us has been able to derive a formula that would quantitatively predict the detailed shape of such a gravitational fusion signal. Closest to reality came the two-pointmasses approximation in Landau and Lifshiz II, § 102 – now well-known as the 'chirp-mass approximation' – which yields a fair description of such an event, or rather: for such an event except for its final $10^{-1.7}$sec before fusion, when it transcends all our attempts. Here is its governing equation:

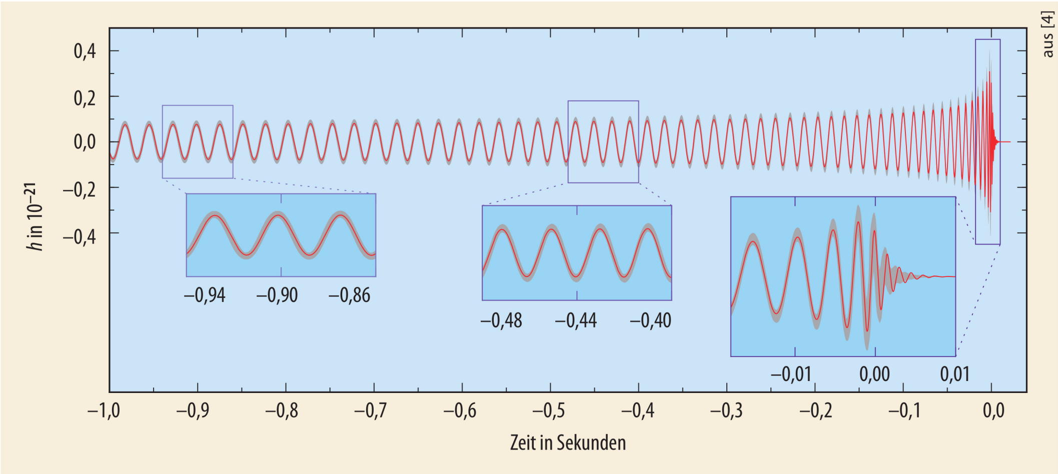

Figure 1: Shape of the recorded terrestrial oscillations of the first 7 GW events detected by Advanced LIGO, between 2015 and 2018. Its frequencies range successively through $\{24, 38, 50, \lesssim 10^3\}$ Hz in the four time windows at $-\{10^2, 0.9, 0.44, \lesssim 0.01\}$ sec .

$$M_c := \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}} = \frac{c^3}{G}\left[\frac{-5}{32\sqrt[3]{2}}\left(\omega^{-8/3}\right)^{\cdot}\right]^{3/5}$$

in which M_c constrains the 2 involved masses m_i, and ω is their common angular velocity around each other. Note that for $m_1 = m_2$, $M_c = 2^{-1/5} m_1 \approx 0.8\ m_1$.

Instead, the publications by [Abbott et al, 2016] listed not only the two masses for their merging objects, but also their spins, and their distance, i.e. they claimed to have resolved three further parameters, which they probably extracted from certain numerical simulations, but which should never have been taken more seriously than as rough speculative estimates. They made me suspicious: as a drastic over-determination, predicted for almost identical-looking signals! Only their last published detection, GW170817, has been monitored long enough – for some 10^2 seconds – to supply reliable estimates of (only) the masses of their mergers: two fusing neutron stars, and their distance from us – both as expected! Here begins new science, with signals lasting for minutes – instead of for msecs – and with independent mass determinations of old, merging binary neutron stars.

For GW170817, even its electrodynamic afterglows have been successfully measured, including its γ-ray burst, whose onset delay – by 1.7 sec – should be understood as caused by the time required for the expansion of its scattered fragments into a large enough volume, in order to be visible from our planet's distance (of 40 Mpc). All the (6) earlier GW signals reached us from much farther away, again from fusing neutron stars, but were incorrectly evaluated by means of the chirp-mass formula (because of their weakness, and implied shortness).

We live in a world without BHs.

4. Cosmic quasi-homogeneity forbids extremely loud distant sources

Astrophysical distance estimates have quite often resulted in over-determinations, in my judgement, by huge factors, most critically for the GRBs, and for the FRBs. Such huge over-determinations can result systematically, in the following 3 ways: 1) The *redshift* of a spectral line can be mistaken to be cosmological, rather than local kinematic; this case often applies to GRBs, if you are unaware of the light-echo geometry of their emissions (which I favour). 2) Rare *lensing* effects can create unexpectedly strong luminosities of nearby point sources, e.g. of FRBs. 3) '*Host galaxies*' are often detected during long-lasting observing sessions: When their observers had finally invested a lot of patience into their finding; he or she regretted to eventually drop them from consideration, even if fake; again, GRBs are often concerned.

In every particular case, the judge should consider quasi-homogeneity of our Universe: A host galaxy of cosmologically large redshift tends to be more than10^8times farther than all interesting Galactic sources of similar type, hence requires a 10^{16}times brighter signal in order to compete with the latter; why did we miss out on all those giganticly brighter signals from our own Galaxy? Doesn't that violate cosmic homogeneity?!

5. The inorganic Machines of the Universe

We present-day humans are quite familiar with facilitating our daily work, hobbies, and fun activities by using tools, transport facilities, and all sorts of muscle-powered and motor-powered 'machines', like bicyles, skates, cars, airplanes, and many others. As humans have built such machines, we know how to construct them, how to repair them, how they function. They involve known materials, constructors, and building plans.

Biological creatures – plants, and animals – involve even more complicated machines in their bodies, like hearts and lungs and stomachs, guts, and outlets, eyes and ears and noses, muscles and nerves and brains, which even repair themselves when hurt, and which can even create children of the same type, or occasionally children of a new type, either of a rather similar type – called 'micro-evolution' – or, more rarely, children of a distinctly different type, called 'macro-evolution' [by David Layzer, 1990]. Just fancy the growth of the baby of a bird, inside an egg that had been dropped into a nest, or just into surrounding sand, and kept at moderately constant temperature by its mother, or father, via 'breeding', for a couple of weeks, until the waking baby bird pierces its solid shell with its beak, and starts its new life. During those couple of weeks, the almost homogeneous, white-yellow egg fluid evolves into the ordered shape and structure of a newborn little bird, some 10^{10}cells of various kinds, and tasks, each of them in the right place, with its proper task, all by themselves, some 10^X processes, with X of order 10^{10} again, each cell in the right place. No human architect could remotely achieve that! We have learned some 50 yr ago – via Whatson & Crick – that all these biological processes are not random processes at all, rather determined by the structure of the double helix DNA which stores all the necessary information, and acts as an engineer at the same time. And we have even found "organizer regions" which steer such processes [Nature 558, 35 (2018)]. Biological processes act often more reliably than machine-made ones! I like to call them 'organic machines'.

So in our Universe – with life on Earth – we avail of *organic machines*, and of *manmade machines*, both of them rather reliable, with building plans to make their creations reproducible. But what about structures in the non-animated, life-less Universe, with matter, radiation, objects, storms around us, in the form of galaxies and galaxy clusters, stars and planets and moons, explosions and collapses: are all of them arbitrary, without working plans or constructors, mere random processes? Or do we again deal with ordered, machine-like processes when we look carefully into the skies? I think of events like *solar-system formations*, *terrestrial volcanism*, *magnetic dynamos*, *stellar winds*, stellar *explosions*, the shape and size of our *heliosphere*, *gravitational shear flows*, *cosmic-ray boosters*, *γ-ray bursters*, and in particular the *astrophysical jet sources* on their various scales. And I like to call them the '*inorganic machines'* of the Universe. They obey strictly the laws of GR, of stable solutions of the Einstein-Maxwell plus particle-physics equations, astrophysicists are sure. We ought to find their detailed structures [Kundt, 2014]. Which can be often quite difficult.

You wonder why I stress the 'machine-made' character of our astrophysical solutions, as a necessary condition? Modern astrophysics likes to approach non-trivial tasks by numerical simulations, often without complete insight into their local structures – with or without BHs – often without checking stability. As one of the best examples, let us consider the jet sources. Do they all obey the same mechanism? I think so. For stability reasons alone, they need an extremely light jet fluid, continually supplied for $\gtrsim$10 Myr for the longest among them: relativistic $e^{\pm}$ pair plasma. Which the sources harvest from magnetic reconnections. A twin jet forms with the help of buoyancy: the newly formed pair plasma rises by buoyancy to both sides of the feeding disk, up and down, gets post-accelerated on their way by low-frequency magnetic waves, (like in the Crab nebula, emitted by the rotating, magnetised, innermost disk), and narrowed in frequency by scattering on the local photon bath, and subsequently transformed from subsonic to supersonic motion by a surrounding, heavy, chimney-like deLaval nozzle formed by the ambient baryonic core plasma. All these conditions are simultaneously provided by a heavy, rotating magnet at the center of an accretion disk, both for the stellar jet sources, and for the galactic ones, provided there is no BH anywhere nearby, (which would damp out all ordered, rising motions by swallowing). In the wide literature, among dozens of simulated jet papers, I have seen none that would have satisfied all the above stability criteria, exception taken by my own paper with Gopal Krishna [Kundt & Krishna, 2004] and its later improvements [Kundt, 2017b], I hope.

6. Summary

Present-day astrophysics is full of inconsistencies; we should be more careful and selective when trying to model its various sources.

Acknowledgements

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DISCUSSION

JIM BEALL: Wolfgang, you agree that neutron stars are objects which are described in part by General Relativity; why do you not also accept the existence of black holes?

WOLFGANG KUNDT: You're asking a key question, Jim! Why do I accept certain astrophysical objects as realistic, whereas I reject others as non-existent? As a decades-long physicist, I want my interpretations to be consistent with all the known observations, and in addition consistent with all their implications for future observations, including the formations, and destructions of their building blocks. So when I cannot see how to form a BH, and when all objects we observe behave differently from the way BHs would behave, I consider BHs as unrealistic building blocks, which ought to be eliminated.