

May GWs signals by BH-BH merging be associated with any γ or ν burst? The case of a $NS - NS$ merging in GW-GRB170817A.

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The Gravitational Wave (GW) events GW150914, GW151226, GW170104 detected by LIGO were a record of Black Hole binary merging system (BH-BH) very probably in nearly empty or a vacuum space; such a kind of events will be mostly with no baryon mass (plasma or dense masses) and therefore mute or blind in any correlated gamma band. By best GW triangulation (as soon as Virgo has been active) their position will be widely located only in a smeared sky (tens or hundred square degree) because of the absence of any correlated spherically-symmetric electromagnetic signal whose photons might be pointing to the exact sources in the sky. If the GWs events might be born inside a globular cluster, a star forming region or along a spiral AGN accretion disk their additional accreting mass may be the needed baryon load to explode and shine: in those dense places BH-BH collapse may also offer an optical-X- γ afterglow via their baryon lightening and photon tracks. However these peculiar orbiting or multi-body systems should also imprint their presence in the inner Kepler period as well as in a perturbed GW signature by unusual time structure. Moreover any Black Hole active (by a relic jets and-or an accretion disk) might shine and blaze during the collapse with a BH by its jet too: however these beams, being extremely collimated, are rarely pointing toward us during the same brief GWs emission. Only very nearby (tens Mpc) BH-Neutron Star (NS) or $NS - NS$ cannibal merging might be associated with a desired, visible and correlated spherical NS explosion (kilonova one); these rare explosion and their GWs might therefore be localized by photon

tracks. But they are lower mass system and they require much lower threshold or just nearer distances. Because of such nearer cosmic volumes (tens Mpc) and because of the very anisotropic beamed GRB associated, these kilohertz event are possibly still very rare and unexpected in gamma sky (even with LIGO Virgo array sky narrow view). However the very exceptional GW170817 GRB170817a event last August 2017 it took place and it was related to a very first $NS - NS$ collapse in a SN-kilonova spherical explosion. This event had been recorded both by its few (day and months) optical transient but as well as by its weak, prompt, short, GRB, two seconds later the same LIGO-Virgo detection. The GRB170817a gamma, X, radio signature it was exceptional in many features and one may wonder and he may ask if it was really correlated to the GWs. Its unique values (softer, weaker, the most near one) made GRB170817a very possibly an off-axis jet detection. However there are solid arguments that suggest that such a GRB are not just blazing within a collimated beam jet but that they are also shining in a wider spread gamma equatorial disk blazing, orthogonal to the jet itself. In a few words we were observing the event not along its jet but mostly orthogonal to it. This GRB170817a geometry may better explain the otherwise unexpected beamed to us event. In this paper therefore we summarize the astrophysical and the cosmological signature of such a long desired multiple astronomy.

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1. Introduction

This article consider the main contribute of recent years LIGO-VIRGO GWs detections. We address toward two main questions: How sharp GW astronomy might be observed and how much relevant are the LIGO GW backgrounds in a known cosmological density frame? Indeed in the following

- 1) first section we discussed as a first approximation the cosmological energy and number fluxes based on the few BH-BH and NS-NS GWs observation in the last few years.
- 2) In the second section we focalized to the GW and its neutrino traces as well as to the expected gamma signal in NS-NS or NS-BH collapse.
- 3) In the third section we remind the additional indirect signal of GWs made by GWs conversion (via galactic or planetary magnetic fields) into a tiny kilo-Hertz radio bangs.
- 4) In the fourth section we considered the BH possible origin.
- 5) In the fifth section we discussed the main nature of multi-carrier signal in NS-NS versus GRB. In particular we briefly analyzed the recent GRB 170817a discover and its probable new peculiar jet morphology.
- 6) In the final conclusion section we summarized the GW future opportunities in view of a revival of LIGO-VIRGO detection and in consideration of a wider visibility of GRB explosion and its jet spread persistence both in a gamma, X, optical and radio disk orthogonal to the thin more collimated, precessing GRB jet.

1.1 A BH-BH collapse making a GWs Astronomy? The present cosmic GW legacy

The advanced Laser Interferometer Gravitational-Wave Observatory (LIGO) [Aasi et al.(2015)] identified two binary black hole coalescence signals two years ago with high statistical significance σ or Signal/Noise, in a summary below:

$$GW151226 \rightarrow 5.3\sigma [\text{Abbott et al.}(2016b)] \quad (1.1)$$

$$LVT151012 \rightarrow S/N9.7; \rightarrow 1.7\sigma \quad (1.2)$$

$$GW150914 \rightarrow 5.1\sigma [\text{Abbott et al.}(2016)] \quad (1.3)$$

$$GW170104 \rightarrow S/N13 [\text{Abbott et al.}(2016c)] \quad (1.4)$$

$$GW170814 \rightarrow S/N18 [\text{Abbott et al.}(2017)] \quad (1.5)$$

$$GW170817a \rightarrow S/N32.4 [\text{Abbott et al.}(2017c)] \quad (1.6)$$

The last GW170104 source is a heavy binary black hole system, with a total mass of of 50 solar ones located at far ($z \simeq 0.2$) cosmic distances (farthest confirmed event to date). More recent BH-BH merging as in GW170608, and in particular in GW170814 observed also by Virgo array, strongly confirmed the ability to record the GWs, but with no electromagnetic signal. Only the most recent and spectacular GW170817, discussed in last section, had the first multi-carrier signature both in GW and in electromagnetic field.

Astronomy is, etymologically, the art of identifying sources in the sky and to collocate them with their names toward the (possible) optical or electromagnetic (EM) counterpart. Many potential astronomy today are still blind or invisible or at best myope: the relic SN neutrinos (yet

to be discovered), the few tens TeV-PeV IceCube neutrinos (not yet correlated to any source), the same Cosmic Rays (CR) bent by galactic magnetic fields or even the Ultra High Energy (UHECR) whose rigidity leads to a myope and-or a coarse astronomy possibly born in recent years [Fargion et al.(2018)], [Fargion et al.(2015)]: (Very recent clustering seem to point to a Local Universe ruled by few star-burst AGN sources as Cen A, M82, NGC 253)

The recent first GW detection by LIGO [Abbott et al.(2016)] on September 14th 2015, it does offer the first view of the huge BH-BH GW energy density or its energy fluency, but not yet any clear source localization. The nominal first event energy fluency and its power fluency (assuming at 400 Mpc distance and assuming a conservative “one a year” event rate, well calibrated with more recent [Abbott et al.(2016c)]) leads to

$$\frac{\Delta E}{4\pi R_{400\text{Mpc}}^2} \simeq \frac{2 \cdot 3 \cdot 10^{33} \cdot 9 \cdot 10^{20} \text{ erg}}{4\pi (1.2 \cdot 10^{27} \text{ cm})^2} \simeq 0.3 \text{ erg cm}^{-2} \text{ sr}^{-1} \quad (1.7)$$

$$\frac{dE}{dA d\Omega dt} = \frac{0.3 \text{ erg}}{3 \cdot 10^7 \text{ cm}^2 \text{ s sr}} \simeq 1.25 \cdot 10^4 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}. \quad (1.8)$$

It might be questioned if such a huge cosmic energy density fluency of $\sim 0.3 \text{ erg cm}^{-2}$ and its apparent brightest power in 0.4 s duration burst over-passed any previous observed radiative one. The unique corresponding energy density fluency has been observed [Yamazaki et al.(2005), Gaensler et al.(2005)] during the giant flare from SGR 1806-20, on December 27th 2004 (just to remind: this was just a day before the largest tragic tsunami in Sumatra, Malaysia). The gamma satellite RHESSI and its particle detector data implied [Hurley et al.(2005)] a spike of fluence in photons at $\geq 30 \text{ keV}$ energy as large as $(1.36 \pm 0.35) \text{ erg cm}^{-2}$. However this SGR event was a galactic one, not a cosmic one. Moreover, just for an historical comparison, the nearest SN 1987A and its neutrino burst from Large Magellanic Cloud (LMC) has been even much more energetic [Hirata et al.(1987)] than the SGR 1806-20 and LIGO GW150914, by nearly a million times. However as being a cosmic event LIGO GW150914 overcame any other GRB or AGN cosmic flare event detected in last century. Also the consequent probable averaged GW flux number and its energy fluency will be enormous respect the EM ones. The LIGO collaboration has evaluated its first GW signal as indebted to a wide range of possible cosmic rate: $2\text{--}400 \text{ Gpc}^{-3} \text{ yr}^{-1}$ where the minimum value of $2 \text{ Gpc}^{-3} \text{ yr}^{-1}$ corresponds to a much (a dozen time) rarer than previous one rate (see equation (1.8)) and at an averaged lower power energy fluency of

$$\frac{dE}{dA d\Omega dt} \simeq 2 \cdot 10^3 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \quad (1.9)$$

which is to be considered as the most “conservative prudential rate”. The two additional events may in average confirm this typical distance. The low GW energy for each characteristic graviton has a frequency on average of $\langle f \rangle_{\text{GW}} = 150 \text{ Hz}$ (and a peak at 250 Hz) leading to a very low energy $E_{\text{GW}} \simeq 6.2 \cdot 10^{-13} \text{ eV} \left(\frac{\langle f \rangle_{\text{GW}}}{150 \text{ Hz}} \right)$ implying an abundant flow of gravitons during the one year rate or $2 \text{ Gpc}^3 \text{ yr}^{-1}$:

$$\frac{dN}{dA d\Omega dt} \simeq 3.2 \cdot 10^{15} \left(\frac{\phi_{\text{GW}}}{2 \text{ Gpc}^3 \text{ yr}^{-1}} \right) \left(\frac{\langle f \rangle_{\text{GW}}}{150 \text{ Hz}} \right)^{-1} \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \quad (1.10)$$

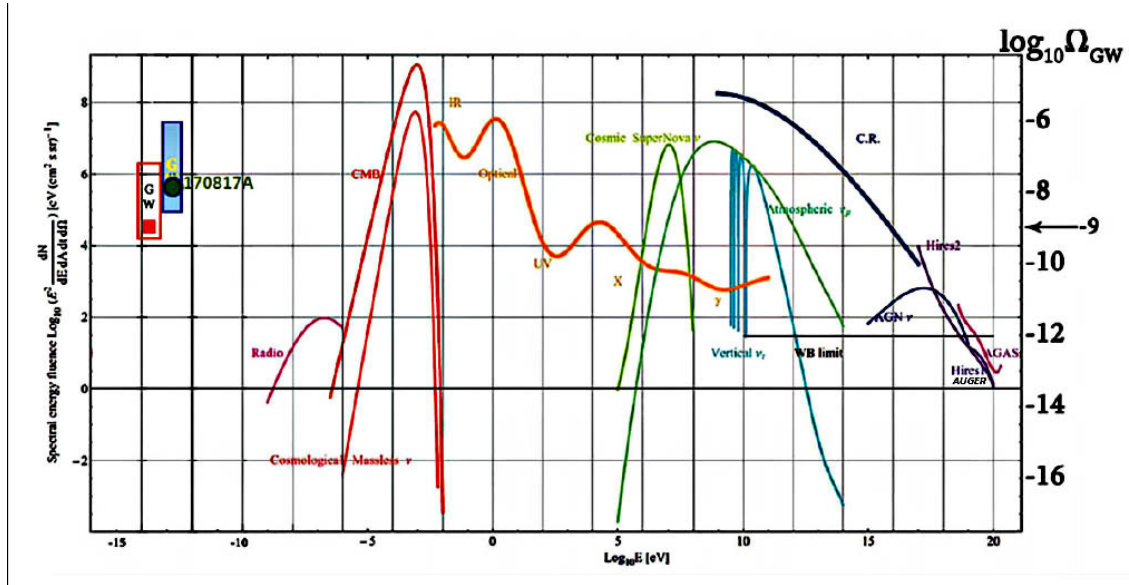


Figure 1: The cosmic energy fluency spectra in logarithmic scale as a function of the particle energy also in logarithmic scale. The huge solar contribute and the high optical galactic plane noise is here ignored. The Big Bang infrared signal is the ruling energy contribute corresponding to nearly $4.7 \cdot 10^{-5} \Omega_c$. The observed LIGO GW in red area and the very probable associated kilohertz additional kHz noise (cyan area) has been marked in approximated box windows. As in the text these energy fluency overcome the corresponding EM ones in gamma and radio by two or more order of magnitude. Note that the optical and infrared e.m. contribute are mostly born in local Universe. Note the relic SN neutrino signals at tens MeV energy whose detection is under rush search in SK (gadolinium implemented) detector, it is somehow comparable to Big Bang infrared signal.

This estimated graviton number flux exceed the 2.7 K cosmic thermal photon number flux by a hundreds times making GWs the most abundant massless cosmic messenger in our universe. Actually, GW in the afterglow of the Big Bang or the very same “virtual” graviton that is keeping the reader sitting on his chair is by many more orders of magnitude the most abundant massless messenger; for an analogy just remind also the well known terrestrial magnetic fields whose virtual photons (huge dense number) are bending our compasses and the Cosmic Rays flight in the Universe; see figure 1.

The more probable binary (a smaller size BH systems, whose smaller mass is of the order of $\sim 3M_\odot$) may be merging at higher frequency at a peak of $f = 2.5$ kHz: these events may contain NS companion whose masses collapse and explosive death are detectable; they are detectable in a narrow located distances by an order of magnitude respect to GW150914 sources and their threshold detection volume is consequently a thousand time smaller; their larger abundance (by a reasonable spectra mass dependence) might compensate (or not) their nearer detection volume leading (or not) to their discover in a near future. Their optical correlation might then be possible. Nevertheless the $30 M_\odot$ BH binary systems and their GWs seem to be a quite dominant signal in the overall cosmic energy fluency at LIGO three events as shown in figure 2. Indeed, the unique detection by LIGO of a short NS NS collapse, discussed in next sections, implies a definite narrow

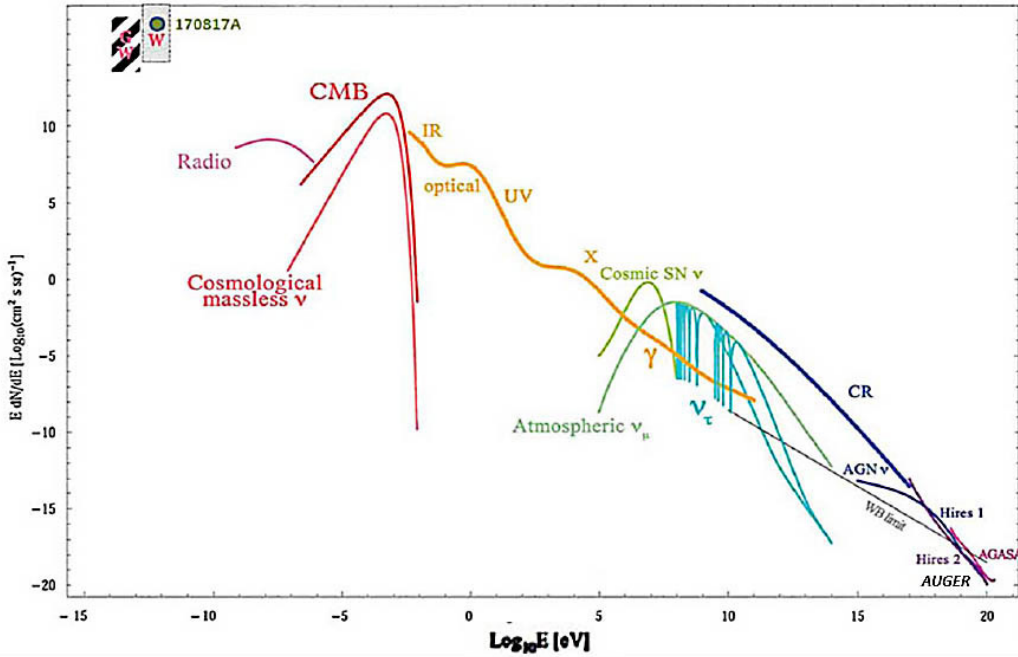


Figure 2: The cosmic number spectra in logarithmic scale as a function of the particle energy also in logarithmic scale. The huge solar contribute and the high optical galactic plane noise is ignored. The Big Bang infrared signal is ruling. The observed LIGO GW is the dashed area and the very probable associated kHz additional noise (gray area) has been marked in a box windows. As in the text these number's contribute overcome the corresponding EM ones in gamma and radio. Note that the optical and infrared contribute are mostly born in local Universe. It will be surprising that such huge GW number flux won't be visible in astronomy but without a correlated EM afterglow information over direction will be almost lost.

windows of GWs of hundreds and thousands Hz, whose fluency are anyway already remarkable in comparison with all the other EM radiations,(see the last section).

As a matter of fact, only the cosmic Black-Body Radiation (BBR) at 2.7 K is still a dominant one ($\phi_{\text{BBR}} \simeq 10^8 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$) as well as the probable and “soon to be detected” ϕ_{SN} relic from all integral Super Novæ, the Cosmic SN ν in figure 1 and in figure 2, which is about $\phi_{\text{SN}} \simeq 10^7 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$. For instance, the most celebrated Gamma Ray Burst (GRB) fluency, in average by Compton satellite, is $\phi_{\text{GRB}} \simeq 10 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$, similar to the UHECR one $\phi_{\text{UHECR}} \simeq 10 \text{ eV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} \left(\frac{E_{\text{UHECR}}}{10^{19} \text{ eV}}\right)^{-2}$, it is usually referred as the Waxmann Bachall (WB) bound it is hundreds or thousands times below the LIGO GW one. The natural consequence is that if a tiny (few percent) component of the GW radiation is transferred to EM waves than the correlation GW-EW signal might be found easily. The GRB with a powerful transient luminosity comparable to 0.1% are the best candidate transient event to be associated. Does this connection occur on GW170817-GRB170817a?

2. A LIGO GW connection to GRB?

From above there are many reasons to foresee a fast e.m. transient associated to these LIGO-

VIRGO astronomy. Indeed there have been a huge attention and attempts to find correlated gamma signals with GWs, with no success. However as we have mentioned the BH BH merging in vacuum is a source only (or mostly) of *silent EM* GWs with no EM tail. Naturally binary collapse in AGN accretion disk or in dense globular cluster may shine in e.m. waves, but their frequency might be rare and their GW signature will be somehow spoiled and disturbed by the third body system and-or mass transfer. Therefore these dense surrounding might be traced in the GW signal anyway. Moreover the surrounding baryon screen will transfer into a gamma signal within an opaque dense wall leading to a long (hours) delay: this is due to baryon photon opacity and its over-Eddington dense electron pair screening. For this reason the very timed (and controversial) gamma flare correlation with LIGO GW150914, event found in FERMI with 0.4 s. detector delay, it seems very improbable. However just during the very first *NS – NS* GW event on 17 August 2017 there have been an outstanding and exceptional GRB 170817A, whose discussion require a additional sections just below and at the article end.

2.1 *NS – NS* or *NS – BH* collapse GRB?

A more noisy neutron binary system while in collapse might be source of GW and also of the associated SN like explosion. However the masses are smaller, the consequent GW signal is much weaker and at higher frequency, the tidal disruption may smear and dilute the GW emission. Also a BH-NS fast cannibal collapse may lead to a very eccentric trajectory encounter or in the late stage of the NS strep-tease to sudden NS instability, causing GWs and an associated NS like a SN correlated explosion [Fargion et al.(2016)]. These events, because a ten times smaller masses, might be observable at much lower (about ten times) intensity and at a consequent much nearer (ten times) distances and at a higher (kHz) frequencies. This foreseen occurrence had been met on GW170817 event, discussed next section. They (*NS – NS*, *NS – BH* merging) are the best candidate for a visible, mostly in optical way, to a correlated GW-SN like explosion [Fargion et al.(2016)]. The possible UHECR trace are not much correlated observable signals (in our lifetime) because of the slow random walk of charged nuclei or even proton, that will held for century to come in a very delayed time scale.

2.2 A GW spherical signal versus a jetted GRB one

Somehow any discover of any (we believed improbable) LIGO GW correlated GRB event it will be a winning signature of the old spherical explosive GRB Fireball model. Indeed the early GRB model has been a very spherical huge explosion: the celebrated Fireball model [Cavallo & Rees(1978)], [Goodman(1986)], [Paczynski(1986)], [Narayan et al.(1992)], [Rees & Meszaros(1994)], [Meszaros & Rees(1993)] on last decades 1980–2000 years. In our-days this spherical model is no longer alive. It has been de-throned by fountain Fireball, whose beam range ten or few degree. However if a spherical GRB would occur, with its associated GW merging, than the EW observation must occur immediately because both GW explosion as well as the GRB burst are almost spherical symmetric. Only a time delay may separate their connection but such connection will be easily found soon. However the GRB has different model today. Indeed, the very high GRB time variability, the huge isotropic power needed and the consequent narrow size of the source (and its high over-Eddington opacity for such GRB hard brightst gamma spectra events) forced most the authors (since 2000s) to consider more and more a beamed fireball-fountain [Waxman(1997),

Wijers et al.(1997), Goldstein et al.(2016)] models whose opening angle is at least as wide as $\frac{\Delta\Omega}{\Omega} \simeq 10^{-3}$. On the other side we offered since the earliest GRB-SN event on April 1998 an even more beamed, persistent model: a very thin jet, blazing and persistent model[Fargion(1999), Fargion(2001), Fargion(2001b)], [Fargion et al.(2016)] $\frac{\Delta\Omega}{\Omega} \simeq 10^{-6} - 10^{-8}$. This jet is spinning and precessing with a decaying output, able to fit by its blazing geometry the early erratic GRB luminosity as well as to explain the very puzzling variable re-brightening of GRB afterglow or their rare, otherwise unexplained, X-ray precursor[Fargion et al.(2006)]. In particular most recent version [Fargion et al.(2016)] based on a NS strep tease by a BH merging guarantees an early electron pair jets (with no neutrino correlated signal) and a late NS fragmentation leading to SN like explosive event. These model explain the rare but puzzling and critical GRB and SN coexistence.

Anyway beamed GRB (Fireball or precessing Jet) are not spherical at all. Therefore the discover, soon or later, of LIGO-VIRGO GW-GRB connection is a benchmark of the GRB model: a spherical GRB will be soon be observed in gamma connection with its GW; a jetted one will be rarely or mostly not observed with the its originating GW. In a more quantitative estimate, the GRB beam pointing inside a solid angle of $\frac{\Delta\Omega}{\Omega} \simeq 10^{-3}$ will need hundreds of events and tens LIGO-VIRGO recording years (even more for our thinner GRB jet model [Fargion et al.(2016)]). The LIGO-VIRGO GW visibility is somehow turned in this Amletic question: GRB, beaming or not beaming jet? as we mentioned only some nearer GRB fed by NS-BH or NS – NS merging may also trace by a parasite SN like explosion in a correlated spherical event. Not the BH-BH merging in a vacuum space. As mentioned above, we believe that the jet beam in GRB is quite narrow, below a few micro steradian so that it may spray in long times in little wider cones. In our view GRB is a persistent jet that it may arise as a precursor (of the same main blaze GRB) and it may occur earlier (days, weeks months) before than the GW event where one of the BH jet and its companion are merged in unique BH. This implies that in general the observation of a GRB in axis occurs at a very rare rate (once every thousands or more) appearing mostly off axis or not at all. The contemporaneous GWs it is therefore very improbable. We now consider an additional tool in GWs detection and BH sources; later on we return to the peculiar GW-GRB connection in NS-NS collapse.

3. The Photon Graviton conversion

The foreseen kHz to-be-observed-soon GW are reminding us of a relevant connection with a parasite EM radiation: the parametric photon-graviton conversion. The G- γ conversion, were first considered in early 60s[Gertsenshtein(1961)] and studied through the last decades [Mitskevich(1970)], [Boccaletti.et.al.(1970)], [Dubrovich(1972)], [Zel’dovich(1974)], [Fargion(1995)], [Dolgov et. al. (2017)]. Gertsenshtein first argued that the coupled gravity-EM energy equation will generate EM waves. Historically, gravity bending light was first proposed by Einstein himself, exactly a century ago. The same Feynman diagram (a real photon plus a virtual graviton of the gravitational object are leading into a scattered photon again), may occur in the opposite way (a real graviton plus a virtual photon are leading to a real photon). The conversion process occurs because, while GWs propagate and squeeze in space-time, they also force the intergalactic magnetic field lines to tremble and vibrate, thus producing a secondary tuned EM waves.

The G- γ conversion process can be interpreted as a secondary effect of gravitational synchrotron radiation[Gertsenshtein&Pustovoit(1962)] and it has been also analyzed by different authors, [Lupanov(1967)], [Sushkov,Khriplovich,1974], [Palazzi&Fargion(1987)], [Fargion(1991)], [Dolgov&Ejlli(2013)]. Let us briefly recall the equations of the GW \rightleftharpoons EW oscillations according to Landau and Lifshits's notation[Landau,Lifshitz(1975)]: let's consider a nearly-flat space-time η_{ik} with a small metric perturbation h_{ik} and let's call the traceless tensor ψ_k^j . We can then write

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}; \quad h_{\mu\nu} = \psi_{\mu\nu} - \frac{1}{2} \psi_{\sigma}^{\sigma} g_{\mu\nu}^0, \quad (3.1)$$

so that the Einstein field equations $G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$ in the linear approximation become

$$\square \psi_{\nu}^{\mu} = \square h_{\nu}^{\mu} = -\frac{16\pi G}{c^4} \tau_{\nu}^{\mu} \quad (3.2)$$

where τ_{ν}^{μ} is the energy momentum tensor (the first equality in equation (3.2) holds because $\psi_{\mu}^{\mu} = 0$). In an external stationary EM field $F^{\sigma\tau(o)}$ and in the presence of a free EW, $\tilde{F}^{\sigma\tau}$, the total EM field is

$$F^{\mu\nu} \equiv F^{\mu\nu(o)} + \tilde{F}^{\mu\nu} \quad (3.3)$$

The corresponding energy-momentum tensor is then

$$\tau_{\nu}^{\mu} = \frac{1}{4\pi} \left[F^{\mu\sigma} F_{\nu\sigma} - \frac{1}{4} \delta_{\nu}^{\mu} (F^{\sigma\tau} F_{\sigma\tau}) \right] \quad (3.4)$$

and

$$\square h_{\nu}^{\mu} = -\frac{16\pi G}{c^4} \tau_{\nu}^{\mu} = -\frac{8G}{c^4} \left[F^{(0)\mu\sigma} \tilde{F}_{\nu\sigma} - \frac{1}{4} \delta_{\nu}^{\mu} (F^{(0)\sigma\tau} \tilde{F}_{\sigma\tau}) \right]. \quad (3.5)$$

In a few words the spacetime squeeze the magnetic stationary fields making them to emit and the photon with the stationary magnetic field couple and makes energy trembling and generating GW: This idea was rediscovered while we proposed (by one of us)[Palazzi&Fargion(1987)] a twin artificial experiment, firstly producing "optical" waves in magnetic tunnels then high energy graviton and later on getting back observable photons; unfortunately this double EW-GW-EW twin conversion is very poor, today, and it is not feasible. This parametric conversion in low radio band in astrophysics is somehow modulated and diluted by the plasma presence that, in a way, makes photons behave as they had a mass. Therefore this GW-EW conversion in space has the damping related to the free charge in space. The conversion $\langle \alpha \rangle$ do not grows quadratically $\langle \alpha \rangle \simeq \frac{G}{c^4} \cdot B^2 L^2$ but just linearly:

$$\langle \alpha \rangle \simeq \frac{G}{c^4} \cdot B^2 L_{\text{Coherence}} L_{\text{Distance}} \quad (3.6)$$

A first conclusion follows: there is much more GW radiation in our universe than the high energy astrophysical one, but these huge low frequency kHz signals has a trace anyway in a tiny radio bang waves [Fargion(1995)] at milli-Jansky threshold fluency. We wonder if these weak signals may be observable in future experiment. We would like to notice that underwater submarine may communicate in these lowest radio frequency. Therefore it might be of interest to verify if any military antenna at ground or better in space may have been recording such a radio bang in correlated GWs event.

4. Black Hole progenitors

There is a negligible probability that two single large $\approx 30M_{\odot}$ will interact and bind and merge as the GW150914 merging event in an average dense cosmology, even in the extreme unrealistic assumption that these BH are the total missing dark matter of the Universe: in the whole history of the Universe this may occur only once (for reasonable speed velocity) much below unity ($\simeq 10^{-4}$) or just few times in a dozen billion years if one assume that these dark matter BHs are clustered in million times denser galaxy volumes. There are other places that may be a catalyzer for such rarest encounter: the inner dense medium of largest giant star (three body event) or along accretion disk or halo of giant AGN BH [Fargion et al.(2016b)]. However these possibilities sound much more rare of a more probable genetic parental birth: the largest giant star binary systems. Such a hottest and most massive double star has been recently discovered in the LMC.

4.1 The Giant star system VFTS 352 origin of BH

The double giant star system VFTS 352 is located about 160000 light-years away in the Tarantula Nebula in LMC. This remarkable region is the most active nursery of new stars in the nearby Universe and new observations from ESO and VLT have revealed that this pair of young stars is among the most extreme and strangest yet found. This system VFTS 352 is composed of two very hot, bright and massive stars that orbit each other in little more than a day. The center of the stars are separated by a dozen of million of kilometers. Their surfaces overlap and a bridge has formed between them. VFTS 352 is not only the most massive known in this tiny class of over-contact binaries it has a combined mass of about 57 times that of the Sun, comparable with the GW150914 binary BH masses. The rarity of such huge giant stellar system stand in front on more mundane and abundant (and less giant) large stars system able anyway to lead to few (3-6) solar mass BH. Therefore there must be a much larger population of lighter (3-6) solar mass BH binary systems whose detection metric deflection is nearly ten times weaker and whose consequent detection distances are ten times smaller inside a nearby Universe.

4.2 Future few solar masses BH GW event at kHz

Therefore the LIGO result may soon lead to detection of nearer $3M_{\odot}$ binary systems masses as it may be better observable via threefold LIGO-Virgo array detection already during few next years or decade. These events would occur in a narrow universe ($\lesssim 40$ Mpc), possibly within the same GZK cut-off as it is for the UHECRs. Naturally, while one might barely hope for an EM afterglow detection, as it has been widely tried and searched for identification (we actually believe, as shown below, that it will be highly improbable), there won't be any possible correlation with the quite lazy and slow and bent UHECR arrival signal hundreds or thousand years later. These expected EM events of few solar masses BH could then be better observed by future higher sensitive LIGO-Virgo array, inside a much narrower universe possibly also correlated to richest dense galaxy clusters. The possibility to reveal a nearby galaxy cluster correlation (like pointing to Virgo or Coma, but not to the individual galaxy or star source) for few solar mass BH system, seem to us the maximal hope of present array GW detectors.

5. A LIGO-VIRGO GW connection to GRB?

If one consider the huge power of the LIGO BH event one may remind the comparable GRB (apparent) huge bursting luminosity. Therefore it is natural to attempt a LIGO connection to EM or neutrino signal somehow correlated to GRB or AGN like flare. At the present no TeV neutrino signal has been found correlated with a GRBs. If the GRB is a blazing ultra-relativistic jet than the inner cone are the most energetic and most collimated component of the jet. The UHE neutrino will be mostly in a thinner hard core of the jet. Therefore the first neutrino event may be probably a precursor of a later secondary (by wider cone gamma jet) gamma signal. If the Gamma correlation will be absent any harder (and more collimated) TeV signal sound even much more improbable. Of course the possibility for such connection (GW-GRB) is related to the binary model and to the expected GRB ejection model. In the far past (let's say until 1999) most models suggested, that GRB were just an ideal spherical symmetric fireball: the nearly spherical symmetric GW signal would or could correlate, soon or later, with the spherical Fireball at same power as a natural candidate source. However the Fireball spherical model is fade away for several reasons and most model imagine GRB as a beamed jet more (as we suggested 0.1°) or less (5°) beamed and collimated cone. In this optics the possibility that a GW (spherical) event does correlate with a beamed GRB jet (usually pointing elsewhere) seem quite unlikely. In case of the GRBs searching for an afterglow (X,optcal,radio) the opposite was taking place: a very beamed MeV photon signal was able to hit anyway wide angle view gamma satellites; then one could easily follow (after Beppo-Sax,Swift..) the X ray afterglow disentangling its inner optical transient. Moreover for GW event there is also a very probable time lag between the its explosions and any correlated erupting signal, that we underline, it is very possibly, pointing elsewhere. However, as in next section, such a GW-GRB connection did take place last year.

5.1 The GW170817-GRB170817A exceptional event

The very recent discover of a first GW170817 by LIGO-Virgo, an event probably indebt to a NS-NS collapse, it correlated with a very rare GRB170817A. Such a connection poses several questions. Indeed the same GRB170817A event exhibited several rare and extreme values all at once: (a) it is the nearest (among several hundreds) short GRB (SGRB) ever detected (40Mpc) (b) it is (among several hundreds) the weakest fluency SGRB ever recorded (c) it is (among several hundreds) the most soft SGRB in whole known SGRB catalogs (d) it is the first NS $\dot{\text{U}}$ NS (or more rare NS $\dot{\text{U}}$ BH) merging GW event ever detected (e) it is the nearest GW event observed (f) it is the first NS $\dot{\text{U}}$ NS merging into a new born NS or a new BH (g) it is (probably) among most powerful energy fluency GW ever observed (h) it is the very first GWs correlated with an afterglows (γ , X, optical). (i) it is (among several hundreds) the very first GRB identified not via its X ray afterglow, but via its day after optical transient. (l) it is (among several hundreds) the most long life GRB brightening (or re-brightening) up now (~ 200 day later).

Giving the very surprising (rare) statistical weight of each of these exceptional parameters, one may reach the conclusion that the GRB time link and the (Fermi) wide sky solid angle correlation, they cannot by themselves be compelling at all in forcing such a GRB-GW link. Indeed if within a radius of 40 Mpc (GRB170817a distance) one may contain (let say) 10^4 galaxies, if the NS-NS event occurs once every 10^4 years, than the NS-NS collapse may take place within a second time

windows by chance only once every $3 \cdot 10^{-8}$. If the time windows enlarge to minutes or hours the correlation factor will be diluted just to just a part over a million. Moreover the simple product of the enlisted statistical weight in values (a-b-c-i-l), assuming for each $\sim 10^{-2}$ average value, it lead to a suppression factor (probability to occur) $\sim 10^{-10}$. This values as well as the geometrical beaming argument expressed above makes the same correlation quite a weak or even meaningless discover. However it is just the same peculiarity of all above values that it makes more acceptable the possibility of an off-axis view of a GRB [Fargion et al.(2017A)]. This has been recognized, later on and with all the detailed GW-GRB data, by most authors [LIGO FERMI (2017)]. The idea that allow the wider view of a lateral GRB has been named with an ad-hoc term: *the structured jet*. We did found a very different road to enlarge the GRB observability, leading to a natural spread signature of the event.

5.2 The GRB170817A jet and its equatorial gamma disk

Indeed for us the idea of an off axis view (of a thin gamma jet) alone was (and it is) not enough to encompass the statistical probability to be at the first GW-GRB connection, within the rare correct tuned solid angle of view (assuming a gamma jet born by electron in Lorentz factor of a hundred or above). For this reason we suggested recently a more natural role of the circular spiral jet shining at a plane γ disk orthogonal to the same jet beam. [Fargion et al.(2017b)] (as shown 3). This geometry amplify the visibility of the GRB170817A by nearly three order of magnitude respect to a view along the thin collimated jet beam. The GRB we model are thin spinning, precessing jet; the consequence of such a geometry it is leading to a much wider view and a longer lifetime of the signal. This long life visibility it has been observed by recent brightening of radio and X GRB170817A afterglow, seven month later.

The solid angle of the thin disk it is still small. If we imagine anyway that the gamma disk it is trembling and precessing as the inner jet the average solid angle may be spread in a wide belt solid angle (see last figure below), making its detection almost as easy as a spherical one.

Indeed since six months of GRB 170817a radio persistence and its brightening after its explosion make the event the most outsider of the GRBs. However in order to converge the poor statistical probability (even for a side view jet) into a more sound and larger value, we suggested that the initial base of the circular jet spiralling electrons does shine (not only) in its final thin collimated beam, but the jet shined also in a very wide spread gamma synchrotron disk, orthogonal to the same narrow jet. This new morphology (gamma disk and narrow late beamed jet) offers a wider solid angle view (and higher probability detection) for nearby distances and a more solid understanding of recent GW-GRB connection, while keeping memory of the past cosmic GRB with a more beamed nature.

This very lateral *side* view geometry, better tuned also with the GRB duration, has been very recently confirmed also as an off-axis afterglow light curves and images from 2D hydrodynamic simulations of double-sided GRB jets in a stratified external medium [Granot et al. (2018)].

In a sentence, we very probably observed the GW-GRB almost in orthogonal side of the jet. However most of the present (still popular) Jet model for GRB are just a single shoot event without any additional survival or persistence. On the contrary our thin persistent GRB jet model [Fargion(1999)], [Fargion(2001)], [Fargion et al.(2006)], [Fargion et al.(2016)] it is based on an accretion disk relic of a cannibal collapse (NS-NS or NS-BH) able to feed for long time a jet , whose

power may even apparently re-brightening by a geometry bending and a more collimation to the observer. Such a persistence indeed it is apparent in GRB170817A, [Bing Li et al.(2018)]. This lightening model (in axis or just side lateral view) survive also if we consider the γ disk shining while its main jet it is being spinning, bent and trembling in different orthogonal directions. Naturally the polarization of the Jet it is the main probe of its synchrotron nature, while the life persistence it is the test of a permanent (even if slowly decaying) thin precessing jet and its linked orthogonal gamma disk. Just to view an analogy we show below the Eta Carina nebula image, whose spread inner twin precessing jet shine an apparent hour glass envelope, while the brightest orthogonal radial spread arrows possibly show the twin gamma disk, whose pressure eject gas in a radial disk winds.

5.3 The NS-NS thermal MeVs neutrino burst

A GW-GRB correlation might in next decade discover a signal by a thermal tens MeV neutrinos born in nearest GW-GRB explosion as soon as Hyper-Kamiokande (in Japan and in Korea) future Megaton detectors, may reach a threshold of detection at a few Mpc distances. The NS-NS neutrino emission may be comparable or just less than a SN one [Fargion et al.(2016)]. LIGO-VIRGO array may soon increase their sensitivity able to reveal also a GW by anisotropic SN collapse in few Mpc distances. The few Mpc size imply a very rare detection of similar NS-NS in next decades, but a well probable one in case of an anisotropic SN explosion by tens MeV neutrino and by kilohertz GW possibly recordable by improved LIGO-VIRGO or even LISA antennas. Indeed the NS-NS emission will be (very probably) ejecting in a spherical symmetry as much as energy as in GW by thermal neutrinos [Fargion et al.(2016)]. In analogy the same NS-NS collapse neutrino signal, from similar distance as GRB 170817a might rise soon at ten Mpc in a more large and crowded neutrino array detector as an implemented Gigaton one, able to observe neutrinos also at tens MeV energy thresholds.

6. Conclusions

The GW astronomy is a great piece in the widest astronomy puzzle. The LIGO-VIRGO discover has been a great achievement. Its understanding it is not obvious and the GRB morphology it is not a usual GRB blazing lighthouse.

The possibility that future LIGO-VIRGO tens solar mass BH-BH merging are catalyzed along dense AGN BH accretion disk might (as in extreme heavy ones [Fargion et al.(2016b)]) soon or later been revealed also by additional Kepler and Lorentz viscous imprint inside the detailed GW tail structure. For instance additional peculiar Shapiro phase delay within the GW structure [Fargion,Conversano(1997)] or viscous forces during the BH-BH GW emissions. In a such a rush and a search for an astronomy, as we mentioned above, there is room to search for NS-NS or light BH merging at Kilo-Hertz also for a rare GWs conversion (by galactic or planetary magnetic fields) into kHz radio waves [?, ?], [Fargion(1995)], [Dolgov et. al. (2017)]; in particular by searching for correlated GW event in radio bangs captured in the lowest frequency military radio band records, low frequency used for most secret submarine communicate systems.

The very recent lucky GW-GRB 170817A event, its first kilonova explosion (possibly related to a minor relic NS fragment explosion [Fargion et al.(2016)]) and the optical transient allowed

anyway to disentangle a very first tag to a sharp GW astronomy. The proposed gamma disk morphology orthogonal to the thin GRB precessing jet might take place and it could enlarged its detection; such a spread shining promises more and more of their discoveries in nearby space (few tens Mpc) as soon as the GW array antenna will be back at record. This very lateral *side* view geometry, better tuned also with the GRB duration, has been very recently confirmed also as an off-axis side view afterglow light curves and images from 2D hydrodynamic simulations of double-sided GRB jets in a stratified external medium [Granot et al. (2018)]. The more collimated gamma thin jet in GRB arise at later advanced relativistic spiral turns more vertical ones: their narrow cones and solid angle shine brighter from far distant edges and from larger cosmic volumes. This peculiar GRB geometry may also offer a reading key of known but un-explained relic nebulae, like the well known Eta Carina or Crab one, a jet possibly fed by a persistent accretion disk falling into a NS or BH.

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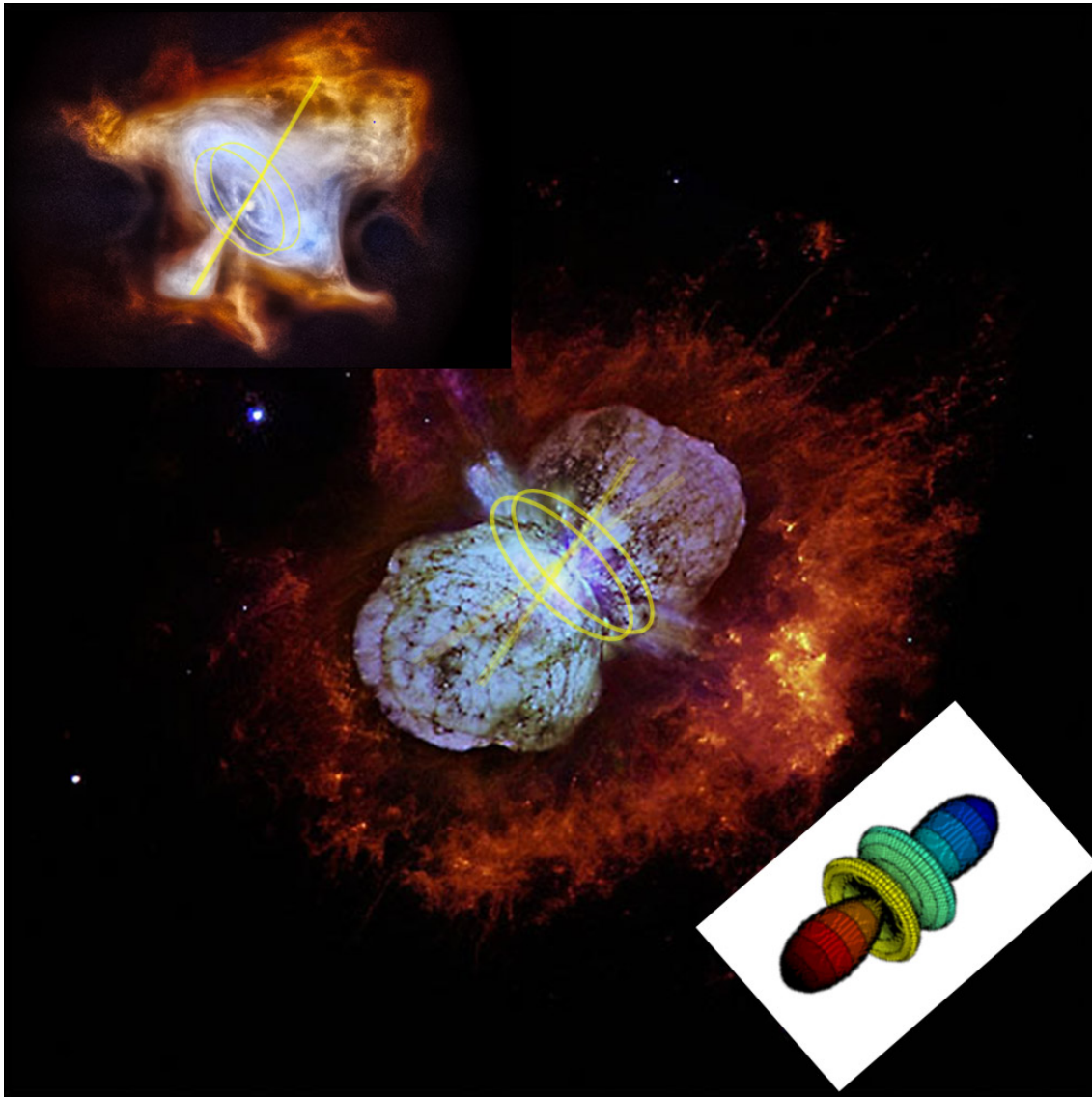


Figure 3: Crab Nebula on the top left side: we suggest that the Crab nebula powered by an old gamma pulsar resemble by its geometry a spinning and precessing jet that it is also shining (at the equatorial edges by their spirally UHE electron in a jet column) a twin orthogonal gamma disk. In analogy, at the figure center, we suggest that Eta Carinae nebula show similar geometry. Its morphology suggest an old hour glass fed by a twin jet and its orthogonal spread disk it is powered, possibly, by its orthogonal twin gamma disk. We see in these pictures the relic gas ejected and pressured and illuminated by those gamma radiation. This geometry might resemble the GRB170817a one; we, the terrestrial observers, have been located along the wider gamma disk solid angle and not along the very narrow thin jet cone as it occurs on the other cases, in most far cosmic, aligned, hard and brightest GRB. On the right side bottom an exemplified multi-pole figure that summarized the gamma luminosity profile and its spinning and precessing signal in a very reduced scale: the inner jet cone might be collimated (even if precessing, spread and and persistent) many millions times than spherical shells while its thin gamma disk may be shine in a much wider solid angle offering a much higher probability to be observed but at a much less amplified (just from tens to a thousand times) than any spherical explosive luminosity.