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SHORT GAMMA-RAY BURSTS FROM THE MERGER OF TWO BLACK HOLES

Rosalba Perna[1], Davide Lazzati[2], and Bruno Giacomazzo[3,4]
[1] Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY, 11794, USA
[2] Department of Physics, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331, USA
[3] Physics Department, University of Trento, via Sommarive 14, I-38123 Trento, Italy
[4] INFN-TIFPA, Trento Institute for Fundamental Physics and Applications, via Sommarive 14, I-38123 Trento, Italy
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ABSTRACT

Short gamma-ray bursts (GRBs) are explosions of cosmic origins believed to be associated with the merger of two compact objects, either two neutron stars or a neutron star and a black hole (BH). The presence of at least one neutron star has long been thought to be an essential element of the model: its tidal disruption provides the needed baryonic material whose rapid accretion onto the post-merger BH powers the burst. The recent tentative detection by the *Fermi* satellite of a short GRB in association with the gravitational wave signal GW150914 produced by the merger of two BHs has challenged this standard paradigm. Here, we show that the evolution of two high-mass, low-metallicity stars with main-sequence rotational speeds a few tens of percent of the critical speed eventually undergoing a weak supernova explosion *can* produce a short GRB. The outer layers of the envelope of the last exploding star remain bound and circularize at large radii. With time, the disk cools and becomes neutral, suppressing the magnetorotational instability, and hence the viscosity. The disk remains “long-lived dead” until tidal torques and shocks during the pre-merger phase heat it up and re-ignite accretion, rapidly consuming the disk and powering the short GRB.

Key words: accretion, accretion disks – gamma-ray burst: general – gravitational waves – stars: black holes – stars: massive

1. INTRODUCTION

The recent detection of gravitational waves (GWs) from the merger of a massive stellar binary black hole system (BH; Abbott et al. 2016) has opened a new window for the observation of the universe. The GW signal was determined to be produced by the final inspiral and ringdown of a binary system of two BHs of masses 36^{+5}_{-4} and $29^{+4}_{-4} M_{\odot}$, at a distance of 0.4 Gpc from Earth. The gamma-ray burst monitor (GBM) on board *Fermi* was serendipitously pointing, at that time, to a region of the sky that intersected with more than 70% of the error region from which the GW signal was detected. Analysis of the data revealed the presence of a mildly significant source of hard X-rays/soft gamma-rays 0.4 s after the GW event, lasting approximately 1 s (Connaughton et al. 2016). The chance significance of the transient was estimated to be 0.0022.

If true, the new source would have properties resembling a weak, short-duration gamma-ray burst (GRB). Its isotropically equivalent energy in the GBM band would amount to $L_{\rm iso} \simeq 2 \times 10^{49}$ erg s^{-1}, about a factor of 10 weaker than a typical short GRB (e.g., Li et al. 2016), but not unprecedented (e.g., GRB080925A; D’Avanzo et al. 2014). While the intrinsic weakness of the burst energetics could suggest that the short GRB was seen off-axis and its true energy is much larger, the hardness of the spectrum requires instead that the burst is seen on-axis and the measured energy corresponds to the true energy budget of the event. If not due to a random fluctuation, the *Fermi* observation points therefore to the association of weak, mildly (if at all) collimated short GRBs with the merging of BH–BH binary systems.

Such an association is somewhat surprising since general consensus requires the presence of at least one neutron star (NS) in the merging compact binary system that generates GRBs (Berger 2014). This requirement is motivated by the need of creating a post-merger BH–accretion disk system. In an NS–NS or NS–BH merger scenario, the NS(s) would be tidally stripped of $\sim$0.1 $M_{\odot}$ of matter during the merger and provide the material for an accreting circum-BH torus (Rezzolla et al. 2010; Giacomazzo et al. 2013). In a clean, double BH merger case, the source of the accreting material was expected to be absent, which is why the *Fermi* data, albeit at low statistical significance, have triggered so much attention. However, we should point out that, following those observations, *INTEGRAL* imaged the same field, but did not identify any source up to a limit on the γ-ray isotropic equivalent luminosity of $E_{\gamma} < 2 \times 10^{48}$ erg, hence questioning the association (Savchenko et al. 2016).

Whether the association between GW150914 and the *Fermi* GBM candidate is real or not, it has raised the possibility that BH–BH mergers may also produce SGRBs, unlike commonly thought. In this Letter, we show that such a scenario is possible within the standard theory of high-mass evolution and accretion disks.

2. FORMATION OF A BINARY BH–BH WITH A FALLBACK DISK

In the following, we consider a typical evolutionary scenario that may lead to electromagnetic radiation in conjunction with a BH–BH merger. As a specific example, we adopt parameter values that would lead to a type of event such as GW150904, but clearly our considerations can be generalized to other initial conditions, and hence the specific model discussed here should simply be considered as a representative case of the new idea that we are proposing.

The starting point for this representative case is a high-mass binary system with stars of masses in the 30 to 40 $M_{\odot}$ range and metallicity $Z \lesssim 0.1 Z_{\odot}$. If the two stars were to evolve without interaction, such as in a detached binary, then, for this range of initial masses, a BH is generally expected to be formed either through a partial or a full fallback of the envelope (e.g., Fryer & Kalogera 2001; Heger et al. 2003). However, there are several other key properties of the stars beyond their initial masses, as well as elements of stellar evolution, which greatly influence this simple picture. In particular, metallicity plays a fundamental role in mass loss since a higher metallicity results in stronger radiation-driven winds (e.g., Vink et al. 2001; Mokiem et al. 2007), and at high metallicities NSs are predicted to become an increasingly more common remnant (e.g., Heger et al. 2003). Additionally, the initial rotational velocity of the star also affects evolution since it influences elemental mixing within the envelope, as well as angular momentum transport (e.g., de Mink et al. 2009). The latter, as discussed more in the following, is also highly dependent on the uncertain role played by magnetic torques during the evolution of the star.

When stars evolve in a binary system, in addition to the elements discussed above, binary interactions also play an important role, and many studies have been devoted to model these interactions with various degrees of sophistication (for a review of the channels forming a double BH system, see, e.g., Kalogera et al. 2007; Belczynski et al. 2010). If the stars are rapidly rotating and remain chemically homogeneous and compact throughout their lifetime without becoming giants, then they may evolve without exchanging mass (e.g., de Mink et al. 2009). However, in close binary systems in which stars evolve to the giant phase, the exchange between the two stars can be dramatic, including non-conservative mass transfer (e.g., Dominik et al. 2012).

However, despite these interactions, the evolution of the mass gainer star after the accretion episode is found to be almost identical to that of a star evolving in isolation with the same mass (Braun & Langer 1995; Dray & Tout 2007). In particular, these authors find that the angular momentum is very similar in the isolated and in the binary evolution cases. While the post-accretion, rejuvenated star is a bit more evolved than the isolated one, these similarities arise because this difference is small compared to the longer secular evolution, and they mainly result in a slightly reduced loss of spin down due to mass loss during core hydrogen burning.

Given the above and the limited studies of the pre-supernova (SN) interior structure of rotating stars in interacting binaries (e.g., Yoon et al. 2010 studied stars with initial mass of the binary component in the 12–25 $M_\odot$ range), here we consider some examples of the pre-SN structure of rotating, isolated stars. We emphasize that these models should be simply considered as illustrative of the conditions required in the interior of the star prior to its collapse for our scenario to work.

We have calculated the pre-SN star models using the evolutionary code MESA[5] including rotation (Paxton et al. 2013). The pre-SN star is identified at the time of core collapse, which in turn is defined as the moment when any part of the Fe core is falling with a velocity $\gtrsim 1000\ \mathrm{km\ s^{-1}}$. An important point to note is that these simulations include angular momentum transport via magnetic torques (Spruit 2002). However, the importance of these torques is still a subject of debate, and it may very well vary considerably from star to star. If magnetic torques are negligible during the evolution, then the specific angular momentum of the pre-SN star is considerably higher for the same initial conditions (see, e.g., Figure 4 of Perna et al. 2014), and therefore the requirement of low metallicity in our models would become less stringent.

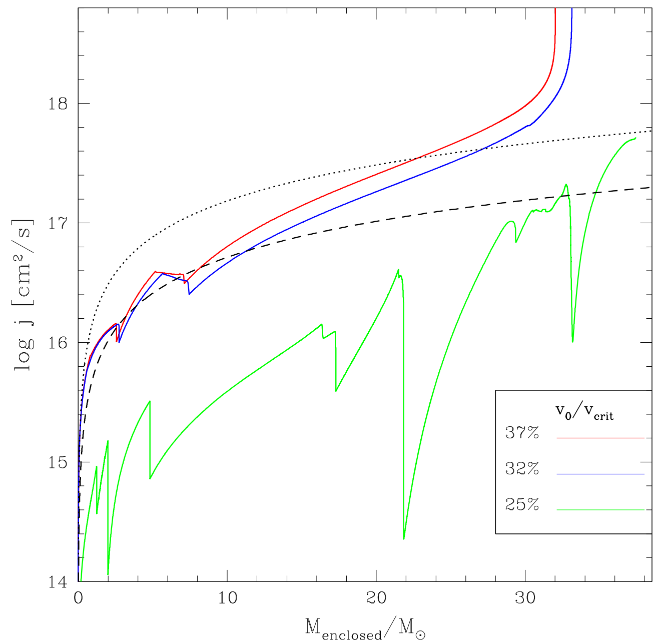

Figure 1. Distribution of specific angular momentum in a pre-SN star of mass $M = 40\,M_\odot$ and metallicity $Z = 0.01 Z_\odot$, for three initial values of the surface equatorial velocity of the main-sequence star, expressed in units of the critical surface equatorial velocity. Also plotted is the specific angular momentum of a particle at the last stable orbit around a Schwarzschild (dotted line) and a Kerr (dashed line) black hole of mass $M = M_{\rm enclosed}$.

Figure 1 shows the distribution of the specific angular momentum in the interior of the star just prior to its explosion, for a main-sequence star of mass $M = 40\,M_\odot$, metallicity $Z = 0.01\,Z_\odot$, and three values of the initial equatorial rotational speed. Also indicated is the specific angular momentum of a particle in a corotating orbit at radius R around a BH of spin parameter $a = 0$ (dotted line) and $a = 1$ (dashed line), where (e.g., Shapiro & Teukolsky 1983)

$$j(R) = \frac{\sqrt{GMR}\,[R^2 - 2(a/c)\sqrt{GMR/c^2} + (a/c)^2]}{R\,[R^2 - 3GMR/c^2 + 2(a/c)\sqrt{GMR/c^2}\,]^{1/2}}. \quad (1)$$

Here, M is the mass of the BH and $J = aM$ its angular momentum.

The pre-SN models of Figure 1 are characterized by the fact that the outer envelope layers are endowed with a specific angular momentum $j_m > j(R_{\rm lso})$, where $R_{\rm lso}$ is the radius at the last stable orbit. This is a structure that we envisage in at least one of the two stars, preferably the second one to go off as SN, since any fallback material left over from the first SN may be blown away when the second star explodes. The models chosen here, with an initial metallicity of $Z = 0.02$, have been selected to straddle a range of critical velocities over which the star transitions from an evolution with strong compositional gradients and a red-giant phase to a chemically homogeneous evolution that bypasses the core-envelope structure. The critical surface equatorial velocity $v_{\rm crit}$ is defined as $v_{\rm crit}^2 = (1 - L/L_{\rm Edd})(GM/R)$, where R is the radius of the star of mass M and $L_{\rm Edd} = 4\pi cGM/\kappa$, with κ as the the opacity. Mass loss to winds is implemented following the prescription of Yoon et al. (2006), which includes a metallicity scaling of line-driven winds. Exponentially decaying overshoot

[5] We used version 4770. The inlist can be downloaded from http://www.astro.sunysb.edu/rosalba/inlist.

at the convective boundaries is included with a mixing parameter $f = 0.005$ (Paxton et al. 2011). We used a standard 25 isotope nuclear network (approx25.net). Transport of angular momentum and chemicals due to rotationally induced instabilities is implemented in a diffusion approximation (e.g., Heger et al. 2000). Convection and the Eddington–Sweet circulations are believed to be the dominant mixing processes during the main sequence of rotating massive stars (e.g., Paxton et al. 2013). In the models, we initialized rotation and defined $t = 0$ (zero-age main sequence) when the total nuclear luminosity generation is at least 95% of the total stellar luminosity.

Before continuing, we should note that the idea that SN explosions may leave behind long-lived disks has a long history in the literature, dating as far back as Colgate (1971) and Chevalier (1989). However, the focus has always been on fallback disks around NSs rather than BHs, since the former display a wide range of observable phenomena that can be accounted for with such disks, from enhanced emission in the anomalous X-ray pulsars (Chatterjee et al. 2000; Alpar 2001a), to anomalous braking indices in pulsars (Menou et al. 2001a), to jets in pulsars (Blackman & Perna 2004), to transient pulsars (Cordes & Shannon 2008), to the making of planets (Lin et al. 1991). These long-lived fallbacks have been shown to be observable up to ages $\sim 10^4 - 10^5$ years at long wavelengths, especially the infrared (Perna et al. 2000), and a detection of a fallback disk has indeed been made (Wang et al. 2006). In the context of BHs, the focus has traditionally been on the rapidly accreting, short-lived disks that power the long GRBs, since these are connected to a well-established observational phenomenology. However, the possibility of long-lived disks also around BHs has been introduced by Perna et al. (2014). While the motivation there was to explore the possibility of planet formation around BHs, those calculations provide the context for forming a short GRB during a BH–BH merger, as it will be argued in the following.

In order to leave behind a BH of mass $\sim 30 M_\odot$, stars such as the ones considered in Figure 1 need to undergo a relatively weak explosion. For example, a star with $M = 40 M_\odot$, $Z = 0.01 Z_\odot$ and $v = 37\%$ of the critical speed, would experience $M \gtrsim 30 M_\odot$ of mass in fallback for explosion energies $E \leqslant 10^{51}$ erg (see Figure 6 in Perna et al. 2014). The outer layers of the envelope of these stars, endowed with angular momentum $j_m > j(R_{\rm los})$, will fall back on a dynamical timescale and eventually circularize at the radius $R_{\rm circ}$ where $j_m = j(R_{\rm circ})$. The following evolution of the ring is mediated by viscosity, with a typical timescale

$$t_0(R_{\rm circ}) = \frac{R_{\rm circ}^2}{H^2 \alpha \Omega_{\rm K}} \sim 160\ \alpha_{-1}^{-1}\, m_{30}^{-1/2}\, R_{10}^{3/2} \left(\frac{R}{H}\right)^2 \,{\rm s}, \quad (2)$$

where $R_{10} = R/(10^{10}\,{\rm cm})$, $m_{30} = M/(30\, M_\odot)$, H is the disk scale-height, $\Omega_{\rm K}$ is the Keplerian velocity of the gas in the disk, and α the viscosity parameter in units of $\alpha_{-1} \equiv \alpha/0.1$ (Shakura & Sunyaev 1973). The disk height is $H \sim R$ during the early, hot super-Eddington slim disk phase, whereas it is $H \sim 0.1\, R$ once the disk, cooled by photons, becomes optically thick and geometrically thin. After a time $t \sim t_0$, the evolution of the disk accretion rate can be well approximated with a power law (e.g., Cannizzo et al. 1990),

$$\dot{M}_d(t) = \dot{M}_d(t_0)\left(\frac{t}{t_0}\right)^{-\beta} \quad (3)$$

where $\beta = 4/3$ and $\beta = 19/16$ apply during the early slim disk phase and during the later geometrically thin regime, respectively.

As a specific, quantitative example, let us now consider the evolution of one of the pre-SN models shown in Figure 1 and, in particular, the case with main-sequence rotational speed equal to 37% of the critical speed. Assuming a weak explosion so that all the material falls back, we find that the outermost $\sim 0.5\, M_\odot$ of the envelope circularizes at radii of $\sim 10^9 - 5 \times 10^{10}$ cm. While we focus on this fallback material from the pre-SN star for the following discussion, we note that there could be substantially more mass at large radii ejected with the wind and which survives the SN explosion, especially if it is weak and asymmetric. This outer envelope mass is endowed with higher specific angular momentum than the one of the pre-SN star (Paxton et al. 2013), and hence, if not unbound by the explosion, would easily circularize around the BH. In the following, to remain conservative, we limit our discussion to the evolution of the fallback mass alone. If there were more mass around, it would only make our model requirements less restrictive. For the particular model under consideration, the initial accretion rate is on the order of $\dot{M}(t_0) \sim M_d/t_0 \sim 6 \times 10^{-6} M_\odot\,{\rm s}^{-1}$. The disk remains super-Eddington for about 90 years and continues to cool with the accretion rate dropping and the mass gradually depleting.

Accretion can proceed as long as the temperature in the disk remains high enough to maintain the gas at least partially ionized. However, as the temperature drops and the magnetic diffusivity decreases, accretion becomes choked. Numerical simulations of the magnetorotational instability (MRI; Balbus & Hawley 1991) have shown that, at low magnetic Reynolds numbers ($\sim$ a few $\times 10^3$), MHD turbulence and its associated angular momentum transport are significantly reduced (Hawley et al. 1996; Fleming et al. 2000). The power-law evolution of the SN fallback disk gets interrupted, and the disk becomes “dead”[6] (e.g., Menou et al. 2001b). The precise value of the accretion rate at which this happens depends on the specifics of the opacity, and hence the composition of the pre-SN star. For a disk of solar composition, the local stability criterion is (Hameury et al. 1998)

$$\dot{M}_d(R) > \dot{M}_{\rm crit}(R) \simeq 9.5 \times 10^{15}\, m_{10}^{-0.9}\, R_{10}^{2.68}\ {\rm g\ s}^{-1} \quad (4)$$

and slight variations are expected in the case of helium-rich and metal-rich disks (Menou et al. 2001b). For the representative model discussed here, when the disk becomes “dead” it still retains $\sim 5.5 \times 10^{-4} M_\odot$ of its mass. Note that this is sufficient to power a GRB with observed luminosity $L_{\rm iso} \sim 2 \times 10^{49}\,{\rm erg\ s}^{-1}$ such as the one measured for the possible counterpart of GW150914.

From this point on, if the binary is not perturbed by external elements, it will live a long time as a system of two BHs with one surrounded by an inactive disk, until the final plunge rekindles the disk, as discussed in the following.

[6] Note that such a type of disk was detected around an isolated NS, with an estimated age $\gtrsim 10^6$ years (Wang et al. 2006).

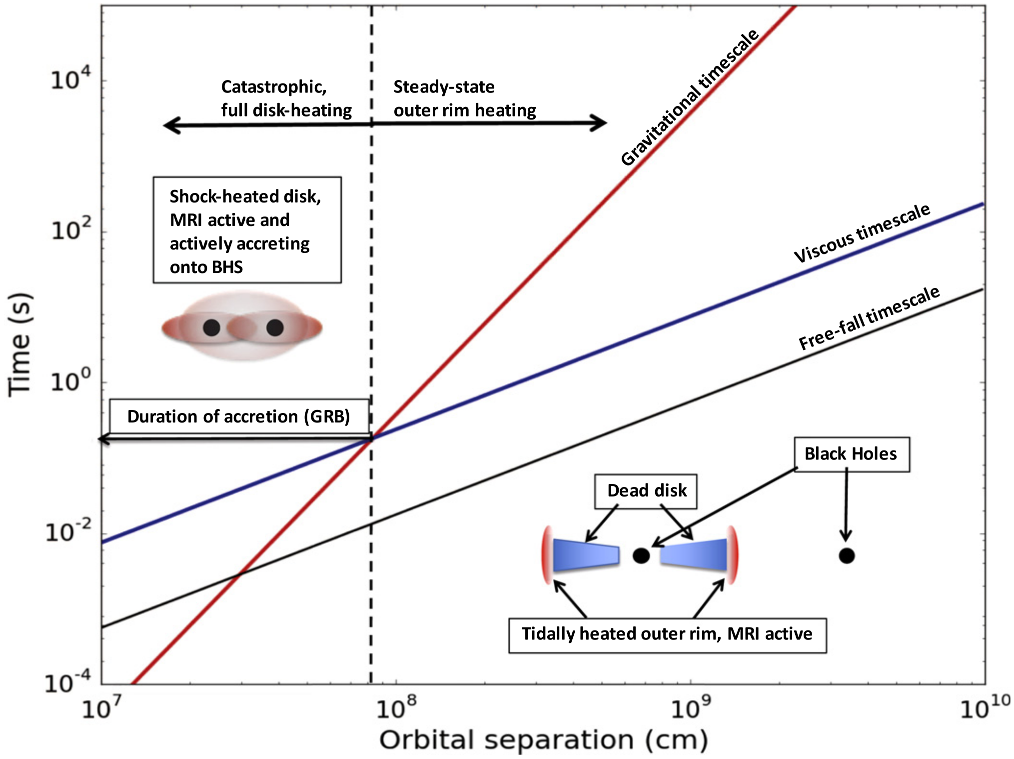

Figure 2. Comparison of the free–free, viscous, and gravitational inspiral timescales as a function of the orbital separation for a system of two $M = 30\ M_\odot$ black holes. One of the two BHs is assumed to be surrounded by a "dead" fallback disk. The disk is reactived once the gravitational timescale becomes smaller than the viscous one. From that point on, the two BHs merge on the very short timescale $t_{\rm GW}$, followed by an electromagnetic emission on the timescale $t_{\rm visc}$.

3. THE FINAL SECONDS: MAKING AN SGRB

Let us now consider the evolution of a binary BH system with a "dead" accretion disk surrounding one of the two BHs (analogous considerations hold for the case in which both BHs have accretion disks). If the outer radius of the accretion disk is smaller than the tidal truncation radius, $R_{\rm TT}$, the disk and the companion BH do not interact significantly[7] (Paczynski 1977; Papaloizou & Pringle 1977; Ichikawa & Osaki 1994; see also Armitage & Natarajan 2002 and Cerioli et al. 2016 for numerical simulations of the "tidal-squeezing" effect). We focus here on a binary BH system with two identical BHs and with orbital separation r. We also assume that the disk and the binary orbits are in the same plane, even though a different geometry should not affect the conclusions of this argument. The tidal truncation radius in this case is $R_{\rm TT} \sim 0.3R$ (Paczynski 1977). For any reasonable parameter set, the viscous timescale at the outer rim of the disk (Equation (2)) is much shorter than the GW inspiral timescale[8] $t_{\rm GW}$ (Hughes 2009; see Figure 2):

$$t_{\rm GW} = \frac{5}{256}\frac{c^5}{G^3}\frac{R^4}{2m^3} = 0.37\frac{R_8^4}{m_{30}^3}\ {\rm s}. \quad (5)$$

In this regime, the bare BH excites tidal dissipation, concentrated in the outer rim of the accretion disk (Papaloizou & Pringle 1977; Ichikawa & Osaki 1994). The associated heating ionizes the outer rim of the disk turning on the MRI. Because the inner part of the disk is still neutral, the material in the outer rim cannot accrete, and hence piles up at the outer edge of the dead zone.

As long as $t_{\rm GW} > t_0$, the system evolves in a quasi steady-state fashion since the disk has time to adjust to the new BH–BH configuration, maintaining an MRI active outer rim pushing against an inactive and non-accreting inner disk. As the binary shrinks, it reaches a point at which $t_{\rm GW} \simeq t_0$. From that moment on, the disk does not have time to adjust to the inspiral of the binary system and the tidal heating reaches the inner part of the disk, likely becoming an impulsive, shock-driven event rather than a quasi-stationary process, analogously to what is seen in numerical simulations of extended disks surrounding a central binary BH (Farris et al. 2015).

The critical radius $r_{\rm crit}$ at which the two timescales are equal is readily derived from Equations (2) and (5):

$$r_{\rm crit} = 3.45 \times 10^7 \left(\frac{R}{H}\right)^{4/5} \frac{m_{30}}{\alpha_{-1}^{2/5}}\ {\rm cm}. \quad (6)$$

The accretion phase is very rapid since the disk is very compact due to the accumulation of material at the outer rim that took place during the inspiral. If accretion produces the launching of a relativistic jet—as seen in SGRBs (Berger 2014) and in tidal disruption events (Burrows et al. 2011)—and the relativistic jet radiates in gamma-rays, we can derive the burst duration from

[7] Particles orbiting outside the tidal radius are more significantly affected by the presence of the companion BH, whose tidal effects would cause their orbits to be perturbed and intercept each other, in the absence of any form of viscosity (Papaloizou & Pringle 1977).

[8] We note that the presence of a disk around one of the BHs will generally influence the angular momentum of the binary, and hence the merger timescale; however, the effect is expected to be significant only if the mass of the disk is at least comparable with that of the companion BH (Lodato et al. 2009).

the viscous timescale at the critical radius, obtaining

$$t_{\rm GRB} = 0.005\left(\frac{R}{H}\right)^{16/5} \frac{m_{30}}{\alpha_{-1}^{8/5}}\ {\rm s}. \tag{7}$$

For a relatively thin disk with, e.g., $(R/H) \sim 3$ at the tidal truncation radius, Equation (7) yields $t_{\rm GRB} = 0.2$ s, in good agreement with the *Fermi* transient associated with GW150914. The burst luminosity depends on the mass accretion rate, which in turns depends on the mass of the disk. A disk with a modest mass of $\sim 10^{-4} - 10^{-3}\ M_\odot$, such as the one discussed in Section 2, would be consistent with the observed luminosity for a standard of $\sim$10% efficiency values for the conversion of accretion power to relativistic outflow and of the outflow power into radiation.

Before concluding, we note that an important condition of our model is that the inner disk, say, $R_{\rm in} \equiv R(t_{\rm GW} = t_0) \lesssim 10^8$ cm, remains cold as long as $t_{\rm GW} > t_0$. A potential disturbance may come from the heated outer rim, which may produce ionizing photons able to heat and ionize the inner regions. In the following, we estimate the magnitude of such a contribution. Let us consider the binary to be at a separation R. The outer radius of the disk is then at $R_d = R_{\rm TT} \sim 0.3R$. The accretion luminosity is $L_{\rm acc} = \eta G M \dot{M}_d/2R_d$, where η is an efficiency factor (from mass to radiation), and $\dot{M}_d \sim M_d/t_{\rm GW}$. We obtain $L_{\rm acc} = 3 \times 10^{39} \eta\ M_{d,-4}\ m_{30}^3/R_{10}^5$ erg s^{-1}, where $M_{d,-4} \equiv M_d/(10^{-4} M_\odot)$. We note that the accretion luminosity becomes sub-Eddington at $R_{10} \gtrsim 1$ and is limited by the Eddington value $L_{\rm E} = 3.7 \times 10^{39} m_{30}$ erg s^{-1} for $R_{10} \lesssim 1$. The number of ionizing photons is $N_{\rm phot} \propto L t_{\rm GW}$, and it drops rapidly as R^4 with orbital separation for radii $R_{10} \lesssim 1$. Hence, for a conservative estimate, we analyze the situation at $R_{10} \sim 1$. Let us assume a typical efficiency $\eta \equiv 0.1\eta_{-1}$. The precise spectral shape of the rim is not well known; hence, we parameterize as $\epsilon_{\rm ph} \equiv 0.1\epsilon_{{\rm ph},-1}$ the fraction of ionizing photons (UV). The emission geometry is also quite uncertain; hence, for simplicity, we consider it isotropic, and we put ourselves in the most conservative case by assuming that the photons are impinging from the rim to the inner disk perpendicularly. Then the only reduction is the geometric factor $(R_{\rm in}/R_{\rm d})^2 = 9(R_{\rm in}/R)^2 = 9 \times 10^{-4} (R_{\rm in,8}/R_{10})^2$, accounting for the fraction of photons from the rim impacting the inner disk. Including these factors, the number of photoionizing photons is $N_{\rm ph} = L_{\rm acc}/(h\nu_{13.6 eV}) t_{\rm GW} \sim 6 \times 10^{52} \eta_{-1} \epsilon_{{\rm ph},-1}\ m_{30}\ M_{-4}^{\rm rim}\ R_{\rm in,8}^2/R_{10}^3$, having indicated with $M_{-4}^{\rm rim}$ the mass in the rim in units of $10^{-4} M_\odot$. This needs to be compared with the number of hydrogen atoms in the inner disk, $N_{\rm H} = M^{\rm inner\text{-}disk}/m_p \simeq 10^{53}\ M_{-4}^{\rm inner\text{-}disk}$. We can hence define a parameter $\zeta = 0.6\eta_{-1}\ \epsilon_{{\rm ph},-1}\ m_{30}\ M_{-4}^{\rm rim}\ R_{\rm in,8}^2\ R_{10}^{-3}\ (M_{-4}^{\rm inner\text{-}disk})^{-1}$, with the understanding that it represents the fraction of the inner disk that could be ionized by the rim prior to the final merger. In order to have the major output of the accretion energy *following* the merger, this quantity has to be small. Otherwise, it would result in a longer, lower-luminosity event *preceeding* the merger.

4. SUMMARY

The discovery of GWs (Abbott et al. 2016) has opened a new window on the universe, and the combined detection of GWs and EM radiation would enormously increase their diagnostic power. The possible detection by *Fermi* of a short GRB-like counterpart to GW150914 has been puzzling in light of the fact that no EM emission was expected from a double BH merger.

Whether this particular association is real or not, it has, however, opened an arena for new ideas to be tested with future dedicated simulations and observations of other GW events. In this spirit, here we have presented a new scenario that, starting from a binary system of two massive, low-metallicity stars, leads to two massive BHs, (at least) one of which is surrounded by a fallback disk at large radii. As the disk cools, it eventually becomes neutral, the MRI is suppressed and the disk can then survive for a very long time as a "dead" disk. Eventually, when the two BHs start their final dance toward the inexorable merger, tidal torques and shocks heat up the gas as the naked BH spirals inward plowing its way within the disk. Accretion resumes from the outer regions toward the inner ones, and the mass pile-up propagates inward as the inner parts of the disk gradually get revived. Immediately following the merger, the disk is fully revived, and the mass piled up hence accretes very rapidly, giving rise to a short GRB.

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