Snowmass2021 - Letter of Interest

Fundamental physics with gravitational wave detectors

Thematic Areas: (check all that apply □/■)

■ (CF1) Dark Matter: Particle Like
■ (CF2) Dark Matter: Wavelike
■ (CF3) Dark Matter: Cosmic Probes
□ (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
□ (CF5) Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before
□ (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
■ (CF7) Cosmic Probes of Fundamental Physics
■ (TF09) Cosmology Theory
■ (TF10) Quantum Information Science Theory

Contact Information:
Emanuele Berti (Johns Hopkins University) [berti@jhu.edu],
Vitor Cardoso (Instituto Superior Técnico, Lisbon) [vitor.cardoso@ist.utl.pt],
Bangalore Sathyaprakash (Pennsylvania State University & Cardiff University) [bss25@psu.edu],
Nicolás Yunes (University of Illinois at Urbana-Champaign) [nyunes@illinois.edu]

Authors: (see long author lists after the text)

Abstract: (maximum 200 words)

Gravitational wave detectors are formidable tools to explore black holes and neutron stars. These compact objects are extraordinarily efficient at producing electromagnetic and gravitational radiation. As such, they are ideal laboratories for fundamental physics and they have an immense discovery potential. The detection of merging black holes by third-generation Earth-based detectors and space-based detectors will provide exquisite tests of general relativity. Loud "golden" events and extreme mass-ratio inspirals can strengthen the observational evidence for horizons by mapping the exterior spacetime geometry, inform us on possible near-horizon modifications, and perhaps reveal a breakdown of Einstein's gravity. Measurements of the black-hole spin distribution and continuous gravitational-wave searches can turn black holes into efficient detectors of ultralight bosons across ten or more orders of magnitude in mass. A precise monitoring of the phase of inspiralling binaries can constrain the existence of additional propagating fields and characterize the environment in which the binaries live, bounding the local dark matter density and properties. Gravitational waves from compact binaries will probe general relativity and fundamental physics in previously inaccessible regimes, and allow us to address fundamental issues in our current understanding of the cosmos.

Motivation. Gravitational-wave (GW) detectors are revolutionary probes of fundamental physics. The LIGO/Virgo detections of black hole (BH) and neutron star (NS) mergers [1], the imaging of a BH shadow by long-baseline radio interferometry [2], and ever more precise observations across all electromagnetic wavelengths have opened a new window on strong gravity. Our ability to understand the interplay between gravity and the other fundamental interactions is at a turning point: just as the last three decades of astronomical observations have revolutionized cosmology, GW observations are moving our understanding of relativistic gravity from the domain of mathematical physics to precision experimental science.

The BH information paradox and the existence of unresolved singularities in classical general relativity (GR) point to deep inconsistencies in our current understanding of gravity and quantum mechanics. These difficulties lie at the heart of recent groundbreaking ideas such as the relationship between entanglement entropy and geometry [3], and they drive efforts to go beyond semi-classical gravity. This led in particular to recent progress on the infrared structure of gravity and quantum field theory, linking memory effects, soft theorems and asymptotic symmetries [4]. It is becoming clear that the main conceptual problems in BH physics hold the key to fundamental issues in theoretical physics. The expectation is that GR must be superseded by a more complete description of gravitational phenomena. The mass range of astrophysical BHs spans about 10 orders of magnitude, therefore Earth- and space-based GW detectors will probe the strong gravity and large curvatures around BHs and NSs over a wide range of masses and frequencies. Our newfound ability to characterize these systems through GWs could give us precious experimental guidance towards a unification of gravity with the other interactions.

Black hole horizons, quantum gravity and the information paradox. In GR, the remnant of a binary BH merger is a distorted BH relaxing to a final (Kerr) BH solution via GW emission characterized by a discrete set of quasinormal mode frequencies. Uniqueness results in vacuum GR imply that these frequencies depend only on the BH mass and spin, allowing for powerful spectroscopic tests, in analogy with atomic and molecular spectroscopy [5–8]. The full splendor of GR is imprinted in the complete GW signal, from inspiral to merger. The accurate modeling of the two-body process opens the door for a wide array of tests, probing GR and modified theories of gravity in completely new regimes, including the violent and nonlinear merger process itself [9, 10]. BHs and NSs orbiting around supermassive BHs behave as test masses probing the external geometry. The motion exhibits complicated behavior which can be used – in analogy to geodesy – to provide exquisite measurements of the multipolar structure of the central object's spacetime. In GR, all of these multipoles depend only on the mass and spin of the central BH, so these systems can be used to identify any deviations of the spacetime from the predictions of GR [11, 12]. Every such detection can constrain deviations of the quadrupole moment from the Kerr value at the level of 0.01–1% [13].

An elegant solution of the information paradox within string theory suggests that BH horizons do not exist, being just coarse-grained descriptions of horizonless geometries [14–16]. Rather general arguments indicate that quantum modifications on horizon scales are possible for macroscopic BHs [17]. Features of the near-horizon region, tidal deformability, and energy dissipation at the horizon (if present) leave characteristic imprints in the gravitational waveforms [18]. Quasiperiodic bursts of radiation ("echoes") following the initial postmerger burst and ringdown would be smoking guns of drastic near-horizon modifications [18, 19]. Thus, precision GW astronomy can provide unique tests of quantum gravity effects in BH spacetimes.

Corrections to general relativity, new compact objects. Some of the conceptual issues related to BHs may be resolved by modifications of gravity [20]. This approach naturally leads to the investigation, within the framework of effective field theory, of scalar-tensor theories, massive gravity [21] and higher-order gravity theories, such as Einstein-scalar-Gauss-Bonnet or dynamical Chern-Simons gravity (for reviews see [9, 22–24]). The well-posedness of many of these theories and the nature of BH and NS solutions are largely open issues [9, 25]. These theories, however, can and have been studied as effective field theories to discover that black holes can be hairy and the orbital dynamics of binary systems can be modified, leading to modifications in the GWs emit during inspiral and ringdown [26–28]. The generic excitation of propagating

scalar fields removes energy from the system, forcing the binary to inspiral faster than in GR and affecting the GW phase in potentially observable ways. Besides, the BH uniqueness theorems of GR do not apply in such a broad setup, raising the exciting possibility that BH candidates in our Universe may be exotic compact bodies of an unknown nature, that could be discovered and characterized via GWs [18, 29].

Probing dark matter: black holes as particle accelerators. Dark matter and dark energy represent a substantial fraction of the energy content of the Universe. There is the exciting possibility, to be verified by future observations, that LIGO and Virgo may already have detected dark matter in the form of primordial BHs [30, 31]. We know very little about dark matter, but according to the equivalence principle it should gravitate just like known forms of matter. This implies that rotating astrophysical BHs can be natural dark matter detectors. For example, BHs moving in a dark matter environment will accrete and be subjected to dynamical friction, leading to minute but detectable changes in the GW phase. These effects depend on the nature of dark matter and its properties [32–34]. In addition, models of minicharged dark matter predict the existence of new fermions which possess a fractional electric charge or are charged under a hidden $U(1)$ symmetry [35, 36], leading to charged BH solutions and a different inspiral and merger signal [37–39].

Astrophysical BHs span about ten orders of magnitude in mass. The corresponding Schwarzschild radii are comparable with the Compton wavelength of a broad range of dark matter candidates [40]. In the presence of rotation, ultralight bosons can form quasibound states around BHs, even if their initial abundance is negligible [41, 42]. Therefore BHs are natural particle detectors, complementary to terrestrial colliders [25, 42]. Proposed ways to rule out or strongly constrain light bosons as dark matter candidates include the observation of inspiralling BHs, monitoring of monochromatic sources, and a mapping of the mass versus spin distribution of astrophysical BHs [25,42]. Axion-like particles have been proposed in many theoretical scenarios, including variations of the original solution to the strong CP problem of QCD. Thus, self-interactions and couplings with Standard Model fields are important and must be accurately modeled. Such couplings can lead to periodic bursts of light, "bosenovas" and other interesting phenomenology [43, 44]. Superradiant instabilities can also give rise to BHs surrounded by boson "clouds" [45], possibly leading to other GW signatures. Thus, GW detectors can test a broad mass range relevant to string axiverse scenarios, as well as fuzzy dark matter candidates that could naturally explain dark matter haloes [46].

GW propagation and the graviton mass. The time lag between detection at different LIGO/Virgo sites, together with time-of-arrival differences between the GW signal and electromagnetic counterparts to the binary NS system GW170817, have already set impressive bounds on the speed of GWs in the LIGO/Virgo frequency range [47]. This bound alone has placed the most stringent constraints on Lorentz violation in the gravitational sector, surpassing previous bounds by over eight orders of magnitude. Monitoring of the inspiral stage, together with superradiant bounds from spinning BHs, can also provide strong bounds on the dispersion relation of GWs, and in particular on the mass of the graviton. Theories with a massive graviton are appealing, in part, because they may explain the late-time expansion of the Universe without invoking dark energy [21], and recent formulations avoid the van Dam-Veltman-Zakharov instability [21, 48] while leading to modifications during binary inspirals and mergers [49, 50]. The propagation of GWs may also be sensitive to macroscopically large extra dimensions, as well as axion-like parity-violating interactions in the action [22]. Observations of GWs at small and large redshift will experimentally verify these possibilities.

Conclusions. The first LIGO/Virgo observing runs have ushered in the promise of GW astronomy and, with it, the power to test our understanding of gravitational physics, from modifications of GR to hints at the true nature of dark matter. New ground-based GW observatories operating in the audio band, e.g. the Cosmic Explorer [51], Einstein Telescope [52], and Neutron-star Merger Observatory [53], mid-band detector concepts such as MAGIS, AION, AEDGE and DECIGO [54–57], and space-based missions operating in the mHz band, like the Laser Interferometer Space Antenna [58] and TianQin [59], will dramatically advance, and potentially revolutionize, our understanding of the fundamental laws of physics.

References

[1] LIGO Scientific, Virgo collaboration, B. P. Abbott et al., *GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs*, *Phys. Rev.* **X9** (2019) 031040, [1811.12907].

[2] Event Horizon Telescope collaboration, K. Akiyama et al., *First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole*, *Astrophys. J. Lett.* **875** (2019) L1, [1906.11238].

[3] E. Bianchi and R. C. Myers, *On the Architecture of Spacetime Geometry*, *Class. Quant. Grav.* **31** (2014) 214002, [1212.5183].

[4] S. W. Hawking, M. J. Perry and A. Strominger, *Soft Hair on Black Holes*, *Phys. Rev. Lett.* **116** (2016) 231301, [1601.00921].

[5] E. Berti, V. Cardoso and A. O. Starinets, *Quasinormal modes of black holes and black branes*, *Class. Quant. Grav.* **26** (2009) 163001, [0905.2975].

[6] S. Gossan, J. Veitch and B. S. Sathyaprakash, *Bayesian model selection for testing the no-hair theorem with black hole ringdowns*, *Phys. Rev.* **D85** (2012) 124056, [1111.5819].

[7] V. Cardoso and L. Gualtieri, *Testing the black hole 'no-hair' hypothesis*, *Class. Quant. Grav.* **33** (2016) 174001, [1607.03133].

[8] M. Isi, M. Giesler, W. M. Farr, M. A. Scheel and S. A. Teukolsky, *Testing the no-hair theorem with GW150914*, *Phys. Rev. Lett.* **123** (2019) 111102, [1905.00869].

[9] E. Berti et al., *Testing General Relativity with Present and Future Astrophysical Observations*, *Class. Quant. Grav.* **32** (2015) 243001, [1501.07274].

[10] N. Yunes and X. Siemens, *Gravitational-Wave Tests of General Relativity with Ground-Based Detectors and Pulsar Timing-Arrays*, *Living Rev. Rel.* **16** (2013) 9, [1304.3473].

[11] F. D. Ryan, *Accuracy of estimating the multipole moments of a massive body from the gravitational waves of a binary inspiral*, *Phys. Rev.* **D56** (1997) 1845–1855.

[12] J. R. Gair, M. Vallisneri, S. L. Larson and J. G. Baker, *Testing General Relativity with Low-Frequency, Space-Based Gravitational-Wave Detectors*, *Living Rev. Rel.* **16** (2013) 7, [1212.5575].

[13] S. Babak, J. Gair, A. Sesana, E. Barausse, C. F. Sopuerta, C. P. L. Berry et al., *Science with the space-based interferometer LISA. V: Extreme mass-ratio inspirals*, *Phys. Rev.* **D95** (2017) 103012, [1703.09722].

[14] S. D. Mathur, *The Information paradox: A Pedagogical introduction*, *Class. Quant. Grav.* **26** (2009) 224001, [0909.1038].

[15] I. Bena and D. R. Mayerson, *A New Window into Black Holes*, 2006.10750.

[16] M. Bianchi, D. Consoli, A. Grillo, J. F. Morales, P. Pani and G. Raposo, *Distinguishing fuzzballs from black holes through their multipolar structure*, 2007.01743.

[17] S. B. Giddings, *Astronomical tests for quantum black hole structure*, *Nat. Astron.* **1** (2017) 0067, [1703.03387].

[18] V. Cardoso and P. Pani, *Testing the nature of dark compact objects: a status report*, *Living Rev. Rel.* **22** (2019) 4, [1904.05363].

[19] V. Cardoso, E. Franzin and P. Pani, *Is the gravitational-wave ringdown a probe of the event horizon?*, *Phys. Rev. Lett.* **116** (2016) 171101, [1602.07309].

[20] A. Joyce, B. Jain, J. Khoury and M. Trodden, *Beyond the Cosmological Standard Model*, *Phys. Rept.* **568** (2015) 1–98, [1407.0059].

[21] C. de Rham, *Massive Gravity*, *Living Rev. Rel.* **17** (2014) 7, [1401.4173].

[22] S. Alexander and N. Yunes, *Chern-Simons Modified General Relativity*, *Phys. Rept.* **480** (2009) 1–55, [0907.2562].

[23] T. Clifton, P. G. Ferreira, A. Padilla and C. Skordis, *Modified Gravity and Cosmology*, *Phys. Rept.* **513** (2012) 1–189, [1106.2476].

[24] T. P. Sotiriou, *Black Holes and Scalar Fields*, *Class. Quant. Grav.* **32** (2015) 214002, [1505.00248].

[25] L. Barack et al., *Black holes, gravitational waves and fundamental physics: a roadmap*, *Class. Quant. Grav.* **36** (2019) 143001, [1806.05195].

[26] N. Yunes, K. Yagi and F. Pretorius, *Theoretical Physics Implications of the Binary Black-Hole Mergers GW150914 and GW151226*, *Phys. Rev.* **D94** (2016) 084002, [1603.08955].

[27] E. Berti, K. Yagi and N. Yunes, *Extreme Gravity Tests with Gravitational Waves from Compact Binary Coalescences: (I) Inspiral-Merger*, *Gen. Rel. Grav.* **50** (2018) 46, [1801.03208].

[28] E. Berti, K. Yagi, H. Yang and N. Yunes, *Extreme Gravity Tests with Gravitational Waves from Compact Binary Coalescences: (II) Ringdown*, *Gen. Rel. Grav.* **50** (2018) 49, [1801.03587].

[29] B. Guo, S. Hampton and S. D. Mathur, *Can we observe fuzzballs or firewalls?*, *JHEP* **07** (2018) 162, [1711.01617].

[30] S. Bird, I. Cholis, J. B. Muñoz, Y. Ali-Haïmoud, M. Kamionkowski, E. D. Kovetz et al., *Did LIGO detect dark matter?*, *Phys. Rev. Lett.* **116** (2016) 201301, [1603.00464].

[31] B. Carr and F. Kuhnel, *Primordial Black Holes as Dark Matter: Recent Developments*, 2006.02838.

[32] E. Barausse, V. Cardoso and P. Pani, *Can environmental effects spoil precision gravitational-wave astrophysics?*, *Phys. Rev.* **D89** (2014) 104059, [1404.7149].

[33] B. J. Kavanagh, D. A. Nichols, G. Bertone and D. Gaggero, *Detecting dark matter around black holes with gravitational waves: Effects of dark-matter dynamics on the gravitational waveform*, 2002.12811.

[34] L. Annulli, V. Cardoso and R. Vicente, *Stirred and shaken: dynamical behavior of boson stars and dark matter cores*, 2007.03700.

[35] A. De Rujula, S. L. Glashow and U. Sarid, *Charged dark matter*, *Nucl. Phys.* **B333** (1990) 173–194.

[36] M. L. Perl and E. R. Lee, *The search for elementary particles with fractional electric charge and the philosophy of speculative experiments*, *Am. J. Phys.* **65** (1997) 698–706.

[37] V. Cardoso, C. F. B. Macedo, P. Pani and V. Ferrari, *Black holes and gravitational waves in models of minicharged dark matter*, *JCAP* **1605** (2016) 054, [1604.07845].

[38] S. Alexander, E. McDonough, R. Sims and N. Yunes, *Hidden-Sector Modifications to Gravitational Waves From Binary Inspirals*, *Class. Quant. Grav.* **35** (2018) 235012, [1808.05286].

[39] G. Bozzola and V. Paschalidis, *General relativistic simulations of the quasi-circular inspiral and merger of charged black holes: GW150914 and fundamental physics implications*, 2006.15764.

[40] G. Bertone and M. P. Tait, Tim, *A new era in the search for dark matter*, *Nature* **562** (2018) 51–56, [1810.01668].

[41] A. Arvanitaki and S. Dubovsky, *Exploring the String Axiverse with Precision Black Hole Physics*, *Phys. Rev.* **D83** (2011) 044026, [1004.3558].

[42] R. Brito, V. Cardoso and P. Pani, *Superradiance*, *Lect. Notes Phys.* **906** (2015) pp.1–237, [1501.06570].

[43] H. Yoshino and H. Kodama, *Bosenova collapse of axion cloud around a rotating black hole*, *Prog. Theor. Phys.* **128** (2012) 153–190, [1203.5070].

[44] T. Ikeda, R. Brito and V. Cardoso, *Blasts of Light from Axions*, *Phys. Rev. Lett.* **122** (2019) 081101, [1811.04950].

[45] C. A. R. Herdeiro and E. Radu, *Asymptotically flat black holes with scalar hair: a review*, *Int. J. Mod. Phys.* **D24** (2015) 1542014, [1504.08209].

[46] L. Hui, J. P. Ostriker, S. Tremaine and E. Witten, *Ultralight scalars as cosmological dark matter*, *Phys. Rev.* **D95** (2017) 043541, [1610.08297].

[47] LIGO Scientific, Virgo, Fermi-GBM, INTEGRAL collaboration, B. P. Abbott et al., *Gravitational Waves and Gamma-rays from a Binary Neutron Star Merger: GW170817 and GRB 170817A*, *Astrophys. J. Lett.* **848** (2017) L13, [1710.05834].

[48] C. de Rham, G. Gabadadze and A. J. Tolley, *Resummation of Massive Gravity*, *Phys. Rev. Lett.* **106** (2011) 231101, [1011.1232].

[49] F. Dar, C. De Rham, J. T. Deskins, J. T. Giblin and A. J. Tolley, *Scalar Gravitational Radiation from Binaries: Vainshtein Mechanism in Time-dependent Systems*, *Class. Quant. Grav.* **36** (2019) 025008, [1808.02165].

[50] C. de Rham, J. Francfort and J. Zhang, *Black Hole Gravitational Waves in the Effective Field Theory of Gravity*, *Phys. Rev.* **D102** (2020) 024079, [2005.13923].

[51] LIGO Scientific collaboration, B. P. Abbott et al., *Exploring the Sensitivity of Next Generation Gravitational Wave Detectors*, *Class. Quant. Grav.* **34** (2017) 044001, [1607.08697].

[52] M. Punturo et al., *The Einstein Telescope: A third-generation gravitational wave observatory*, *Class. Quant. Grav.* **27** (2010) 194002.

[53] K. Ackley et al., *Neutron Star Extreme Matter Observatory: A kilohertz-band gravitational-wave detector in the global network*, 2007.03128.

[54] MAGIS-100 collaboration, J. Coleman, *Matter-wave Atomic Gradiometer InterferometricSensor (MAGIS-100) at Fermilab*, *PoS* **ICHEP2018** (2019) 021, [1812.00482].

[55] L. Badurina et al., *AION: An Atom Interferometer Observatory and Network*, *JCAP* **2005** (2020) 011, [1911.11755].

[56] AEDGE collaboration, Y. A. El-Neaj et al., *AEDGE: Atomic Experiment for Dark Matter and Gravity Exploration in Space*, *EPJ Quant. Technol.* **7** (2020) 6, [1908.00802].

[57] S. Kawamura et al., *Current status of space gravitational wave antenna DECIGO and B-DECIGO*, 2006.13545.

[58] LISA collaboration, P. Amaro-Seoane et al., *Laser Interferometer Space Antenna*, 1702.00786.

[59] J. Mei et al., *The TianQin project: current progress on science and technology*, 2008.10332.

Additional Authors:

Ana Achúcarro (Leiden University) [achucar@lorentz.leidenuniv.nl],
Michalis Agathos (University of Cambridge) [magathos@damtp.cam.ac.uk],
Pau Amaro Seoane (Universitat Politècnica de València) [amaro@upv.es],
Victor E. Ambruș (West University of Timișoara) [victor.ambrus@e-uvt.ro],
Mustafa A. Amin (Rice University) [mustafa.a.amin@rice.edu],
Lorenzo Annulli (Instituto Superior Técnico, Lisbon) [lorenzo.annulli@tecnico.ulisboa.pt],
Stefan Antusch (University of Basel) [stefan.antusch@unibas.ch],
Sofiane Aoudia (Université de Bejaia) [sofiane.aoudia@univ-bejaia.dz],
Alexandre Arbey (University of Lyon) [alexandre.arbey@ens-lyon.fr],
Manuel Arca Sedda (Heidelberg University) [m.arcasedda@gmail.com],
Maria Archidiacono (University of Milano) [maria.archidiacono@unimi.it],
Jérémy Auffinger (University of Lyon) [j.auffinger@ipnl.in2p3.fr],
Anastasios Avgoustidis (University of Nottingham) [Anastasios.Avgoustidis@nottingham.ac.uk],
Vishal Baibhav (Johns Hopkins University) [vbaibha1@jh.edu],
David Bacon (University of Portsmouth) [david.bacon@port.ac.uk],
Tessa Baker (Queen Mary University of London) [t.baker@qmul.ac.uk],
Athanasios Bakopoulos (University of Ioannina, Greece) [a.bakop@uoi.gr],
Csaba Balazs (Monash University) [csaba.balazs@monash.edu],
Elvis Barakovic (University of Tuzla) [elvis.barakovic@untz.ba],
Enrico Barausse (SISSA Scuola Internazionale Superiore di Studi Avanzati) [barausse@sissa.it],
Pedro Bargueno (Universidad de Alicante) [pedro.bargueno@ua.es],
Nicola Bartolo (University of Padova and INFN Sezione di Padova, Italy) [nicola.bartolo@pd.infn.it],
Masha Baryakhtar (New York University) [mbaryakhtar@nyu.edu],
Michał Bejger (Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences) [bejger@camk.edu.pl],
Krzysztof Belczynski (The Polish Academy of Sciences) [chrisbelczynski@gmail.com],
Emilio Bellini (University of Oxford) [emilio.bellini@physics.ox.ac.uk],
Nicola Bellomo (University of Barcelona) [nicola.bellomo@icc.ub.edu],
Ido Ben-Dayan (Ariel University) [idobd@ariel.ac.il],
Peter Bender (University of Colorado) [pbender@jila.colorado.edu],
Marcus Berg (Karlstad University) [marcus.berg@kau.se],
José Luis Bernal (Johns Hopkins University) [jbernal2@jhu.edu],
Laura Bernard (Observatoire de Paris) [laura.bernard@obspm.fr],
Daniele Bertacca (University of Padova and INFN Sezione di Padova, Italy) [daniele.bertacca@pd.infn.it],
Gianfranco Bertone (University of Amsterdam) [g.bertone@uva.nl],
Dario Bettoni (University of Salamanca) [bettoni@usal.es],
Atri Bhattacharya (University of Liège) [A.Bhattacharya@uliege.be],
Neven Bilić (Rudjer Boskovic Institute) [bilic@irb.hr],
Simeon Bird (University of California, Riverside) [sbird@ucr.edu],
Ofek Birnholtz (Bar-Ilan University) [ofek.birnholtz@biu.ac.il],
Diego Blas (King's College London) [diego.blas@kcl.ac.uk],
Jose Luis Blázquez-Salcedo (University of Oldenburg) [jose.blazquez.salcedo@uni-oldenburg.de],
Laura Blecha (University of Florida) [lblecha@ufl.edu],
Béatrice Bonga (Radboud University Nijmegen) [bbonga@science.rul.nl],
Elisa Bortolas (University of Zürich) [elisa.bortolas@uzh.ch],
Matteo Braglia (University of Bologna) [matteo.braglia2@unibo.it],

Marica Branchesi (Gran Sasso Science Institute) [marica.branchesi@gssi.it],
Torsten Bringmann (University of Oslo) [torsten.bringmann@fys.uio.no],
Richard Brito (Sapienza University of Rome) [richard.brito@roma1.infn.it],
Ramy Brustein (Ben-Gurion University) [ramyb@bgu.ac.il],
Tomasz Bulik (University of Warsaw) [tb@astrouw.edu.pl],
Alessandra Buonanno (Max Planck Institute for Gravitational Physics) [alessandra.buonanno@aei.mpg.de],
Riccardo Buscicchio (University of Birmingham) [riccardo@star.sr.bham.ac.uk],
Gianluca Calcagni (IEM-CSIC, Spain) [g.calcagni@csic.es],
Robert Caldwell (Dartmouth College) [robert.r.caldwell@dartmouth.edu],
Francesca Calore (CNRS, LAPTh, France) [calore@lapth.cnrs.fr],
Peter Cameron (Brookhaven Lab - retired) [electronGaugeGroup@gmail.com],
Pedro R. Capelo (University of Zurich) [pcapelo@physik.uzh.ch],
Chiara Caprini (CNRS, APC Paris) [caprini@apc.in2p3.fr],
Andrea Caputo (University of Valencia) [andrea0292@hotmail.it],
Carmelita Carbone (Istituto di Astrofisica Spaziale e Fisica cosmica Milano and INFN Sezione di Milano, Italy) [carmelita.carbone@inaf.it],
Alejandro Cárdenas-Avendaño (University of Illinois at Urbana-Champaign) [ac54@illinois.edu],
José Manuel Carmona (University of Zaragoza) [jcarmona@unizar.es],
Gregorio Carullo (University of Pisa and INFN Pisa, Italy) [gregorio.carullo@ligo.org],
Jose A. R. Cembranos (Complutense University of Madrid) [cembra@fis.ucm.es],
Chia-Feng Chang (University of California-Riverside) [chiafeng.chang@email.ucr.edu],
Sylvain Chaty (Université de Paris, France) [sylvain.chaty@u-paris.fr],
Hsin-Yu Chen (MIT) [himjiu@mit.edu],
Yanbei Chen (California Institute of Technology) [yanbei@caltech.edu],
Maria Chernyakova (Dublin City University) [masha.chernyakova@dcu.ie],
Cecilia Chirenti (University of Maryland) [chirenti@umd.edu],
Sebastien Clesse (Louvain U., Namur U.) [sebastien.clesse@uclouvain.be],
Katy Clough (University of Oxford) [katy.clough@physics.ox.ac.uk],
Geoffrey Compère (Université Libre de Bruxelles) [gcompere@ulb.ac.be],
Lucas Gardai Collodel (University of Tübingen) [lucas.gardai-collodel@uni-tuebingen.de],
Monica Colpi (University of Milano Bicocca) [monica.colpi@unimib.it],
Giuseppe Congedo (University of Edinburgh) [giuseppe.congedo@ed.ac.uk],
Carlo R. Contaldi (Imperial College London) [c.contaldi@imperial.ac.uk],
Adam Coogan (University of Amsterdam) [a.m.coogan@uva.nl],
Isabel Cordero-Carrión (Universitat de València, Spain) [isabel.cordero@uv.es],
Claudio Corianò (University of Salento and INFN Lecce, Italy) [claudio.coriano@le.infn.it],
Neil Cornish (Montana State University) [ncornish@montana.edu],
Djuna Croon (TRIUMF) [dcroon@triumf.ca],
Károly Zoltán Csukás (Wigner Research Centre for Physics, Budapest, Hungary) [csukas.karoly@wigner.hu],
Jean-René Cudell (Université de Liège) [jr.cudell@uliege.be],
Yanou Cui (University of California-Riverside) [yanou.cui@ucr.edu],
Pedro Cunha (Albert Einstein Institute) [pedro.cunha@aei.mpg.de],
Sayak Datta (Inter-University Centre for Astronomy and Astrophysics) [skdatta@iucaa.in],
Anne-Christine Davis (Cambridge University) [ad107@cam.ac.uk],
Valerio De Luca (University of Geneva) [Valerio.DeLuca@unige.ch],
Andrea Derdzinski (University of Zurich, Switzerland) [andrea@ics.uzh.ch],
Kyriakos Destounis (University of Tübingen) [kyriakos.destounis@uni-tuebingen.de],
Jose M. Diego (Instituto de Fisica de Cantabria, Spain), [jdiego@ifca.unican.es],

Eleonora Di Valentino (University of Manchester, UK) [eleonora.divalentino@manchester.ac.uk],
Caterina Doglioni (Lund University) [caterina.doglioin@hep.lu.se],
Guillem Domènech (ITP, Heidelberg University) [domenech@thphys.uni-heidelberg.de],
Fiorenza Donato (University of Torino, Italy) [donato@to.infn.it],
Daniela Doneva (University of Tübingen) [daniela.doneva@uni-tuebingen.de],
Sorin Dragomir (Università degli Studi della Basilicata) [sorin.dragomir@unibas.it],
Amelia Drew (University of Cambridge) [ad652@cam.ac.uk],
Francisco Duque (Instituto Superior Técnico, Lisbon) [francisco.duque@tecnico.ulisboa.pt],
Ruth Durrer (Université de Genève) [ruth.durrer@unige.ch],
Thomas Eberl (Erlangen Centre for Astroparticle Physics) [Thomas.Eberl@fau.de],
John Ellis (King's College London) [John.Ellis@cern.ch],
Timon Emken (Chalmers University of Technology) [emken@chalmers.se],
Roberto Emparan (Universitat de Barcelona, Spain) [emparan@ub.edu],
Cem Eröncel (DESY, Hamburg, Germany) [cem.eroncel@desy.de],
Stéphanie Escoffier (Aix-Marseille University, CPPM) [escoffier@cppm.in2p3.fr],
Domènec Espriu (Universitat de Barcelona) [espriu@icc.ub.edu],
Jose M. Ezquiaga (University of Chicago) [ezquiaga@uchicago.edu],
Malcolm Fairbairn (King's College London) [malcolm.fairbairn@kcl.ac.uk],
Will M. Farr (Stony Brook University / CCA) [will.farr@stonybrook.edu],
Justin C. Feng (Instituto Superior Técnico, Lisbon) [justin.feng@tecnico.ulisboa.pt],
Stanislav Fisenko (MSLU, Russia) [stanislavfisenko@yandex.ru],
Valeria Ferrari (Sapienza University of Rome) [valeria.ferrari@uniroma1.it],
Pedro G. Ferreira (University of Oxford, UK) [pedro.ferreira@physics.ox.ac.uk],
Pau Figueras (Queen Mary University of London) [p.figueras@qmul.ac.uk],
José A. Font (Universitat de València, Spain) [j.antonio.font@uv.es],
Nicolao Fornengo (University of Torino and INFN/Torino, Italy) [nicolao.fornengo@unito.it],
Arianna Foschi (Instituto Superior Técnico, Lisbon) [arianna.foschi@tecnico.ulisboa.pt],
Giacomo Fragione (Northwestern University) [giacomo.fragione@northwestern.edu],
Tassos Fragos (University of Geneva) [anastasios.fragkos@unige.ch],
Gabriele Franciolini (University of Geneva) [Gabriele.Franciolini@unige.ch],
Noemi Frusciante (Instituto de Astrofísica e Ciências do Espaço, Universidade de Lisboa) [nfrusciante@fc.ul.pt],
Javier Galán (Universidad de Zaragoza, Spain) [javier.galan@unizar.es],
Giorgio Galanti (INAF, Osservatorio Astronomico di Brera, Italy) [gam.galanti@gmail.com],
Juan García-Bellido (Universidad Autónoma de Madrid, Spain) [juan.garciabellido@uam.es],
Sebastian Garcia-Saenz (Imperial College London, UK) [s.garcia-saenz@imperial.ac.uk],
László Árpád Gergely (University of Szeged, Hungary) [laszlo.a.gergely@gmail.com],
Davide Gerosa (University of Birmingham) [d.gerosa@bham.ac.uk],
Archisman Ghosh (Ghent University) [archisman.ghosh@ugent.be],
Shrobana Ghosh (Cardiff University) [ghoshs9@cardiff.ac.uk],
Thanasis Giannakopoulos (Instituto Superior Técnico, Lisbon) [athanasios.giannakopoulos@tecnico.ulisboa.pt],
Gian F. Giudice (CERN, Switzerland) [gian.giudice@cern.ch],
Andreja Gomboc (University of Nova Gorica) [andreja.gomboc@ung.si],
Aniello Grado (INAF, Naples, Italy) [aniello.grado@inaf.it],
Stephen Green (Max Planck Institute for Gravitational Physics) [stephen.green@aei.mpg.de],
Ruth Gregory (Durham CPT, UK) [r.a.w.gregory@durham.ac.uk],
Christophe Grojean (DESY, Hamburg and Humboldt University, Berlin, DE) [christophe.grojean@desy.de],
Saskia Grunau (University of Oldenburg) [saskia.grunau@uni-oldenburg.de],
Leonardo Gualtieri (Sapienza University of Rome) [leonardo.gualtieri@roma1.infn.it],

Eduardo Guendelman (Ben Gurion Unversity of the Negev) [guendel@bgu.ac.il],
Anuradha Gupta (The University of Mississippi) [agupta1@olemiss.edu],
Leïla Haegel (Université de Paris, CNRS, Astroparticule et Cosmologie) [leila.haegel@apc.in2p3.fr],
Zoltán Haiman (Columbia University) [zoltan@astro.columbia.edu],
Troels Harmark (Niels Bohr Institute, University of Copenhagen, Denmark) [harmark@nbi.ku.dk],
Roni Harnik (Fermilab, US) [roni@fnal.gov],
Betti Hartmann (IFSC/USP, Brazil) [bhartmann@ifsc.usp.br],
Fawad Hassan (Stockholm University) [fawad@fysik.su.se],
Carl-Johan Haster (Massachusetts Institute of Technology) [haster@mit.edu],
Aurélien Hees (SYRTE, Observatoire de Paris) [aurelien.hees@obspm.fr],
Lavinia Heisenberg (ETH Zurich) [laviniah@phys.ethz.ch],
Carlos Herdeiro (Aveiro University) [herdeiro@ua.pt],
Mario Herrero-Valea (SISSA, Italy) [mherrero@sissa.it],
Thomas Hertog (KU Leuven, Belgium) [thomas.hertog@kuleuven.be],
David Hilditch (Instituto Superior Técnico, Lisbon) [david.hilditch@tecnico.ulisboa.pt],
Tanja Hinderer (Utrecht University) [t.p.hinderer@uu.nl],
Daniel Holz (University of Chicago) [qrs@uchicago.edu],
Yi-Ming Hu (Sun Yat-sen University) [huyiming@sysu.edu.cn],
Eliu A. Huerta (University of Illinois at Urbana-Champaign) [elihu@illinois.edu],
Scott A. Hughes (Massachusetts Institute of Technology) [sahughes@mit.edu],
Sascha Husa (University of the Balearic Islands) [sascha.husa@uib.es],
Gert Hütsi (NICPB, Tallinn) [gert.hutsi@to.ee],
Taishi Ikeda (Instituto Superior Técnico, Lisbon) [taishi.ikeda@tecnico.ulisboa.pt],
Maximiliano Isi (Massachusetts Institute of Technology) [maxisi@mit.edu],
Rajeev K. Jain (Indian Institute of Science, Bangalore, India) [rkjain@iisc.ac.in],
Amruta Jaodand (Caltech) [ajaodand@caltech.edu],
Philippe Jetzer (University of Zürich, Switzerland) [jetzer@physik.uzh.ch],
Cristian Joana (University of Louvain, Belgium) [cristian.joana@uclouvain.be],
Marc Kamionkowski (Johns Hopkins University) [kamion@jhu.edu],
Kristjan Kannike (NICPB, Tallinn) [kristjan.kannike@cern.ch],
Panagiota Kanti (University of Ioannina, Greece) [pkanti@uoi.gr],
Alexandros Karam (NICPB, Tallinn) [alexandros.karam@kbfi.ee],
Alex Kehagias (NTU Athens, Greece) [kehagias@central.ntua.gr],
David Keitel (University of the Balearic Islands) [david.keitel@ligo.org],
Claus Kiefer (University of Cologne, Germany) [kiefer@thp.uni-koeln.de],
Masashi Kimura (Rikkyo University) [mkimura@rikkyo.ac.jp],
Bence Kocsis (University of Oxford) [bence.kocsis@physics.ox.ac.uk],
Kostas Kokkotas (University of Tübingen) [kostas.kokkotas@uni-tuebingen.de],
Shimon Kolkowitz (University of Wisconsin - Madison) [kolkowitz@wisc.edu],
Joachim Kopp (CERN) [jkopp@cern.ch],
Savvas M. Koushiappas (Brown University) [koushiappas@brown.edu],
Ely Kovetz (Ben-Gurion University, Israel) [kovetz@bgu.ac.il],
Kazuya Koyama (University of Portsmouth) [Kazuya.Koyama@port.ac.uk],
Michael Kramer (MPI für Radioastronomie) [mkramer@mpifr-bonn.mpg.de],
Jutta Kunz (University of Oldenburg) [jutta.kunz@uni-oldenburg.de],
Martin Kunz (Université de Genève) [martin.kunz@unige.ch],
Jui-Lin Kuo (Institute of High Energy Physics, Austrian Academy of Sciences) [jui-lin.kuo@oeaw.ac.at],
Claus Lämmerzahl (University of Bremen) [claus.laemmerzahl@zarm.uni-bremen.de],

Ryan N. Lang (Massachusetts Institute of Technology) [rlang@mit.edu],
Edward Larrañaga (Universidad Nacional de Colombia) [ealarranaga@unal.edu.co],
Benjamin V. Lehmann (University of California, Santa Cruz) [blehmann@ucsc.edu],
Marek Lewicki (King's College London) [marek.lewicki@kcl.ac.uk],
Steven L. Liebling (Long Island University) [steve.liebling@liu.edu],
Eugene A. Lim (King's College London) [eugene.a.lim@gmail.com],
Rico K. L. Lo (California Institute of Technology) [kllo@caltech.edu],
Ilídio P. Lopes (Instituto Superior Técnico, Lisboa) [ilidio.lopes@tecnico.ulisboa.pt],
Nicole Lloyd-Ronning (Los Alamos Lab; UNM, Los Alamos) [lloyd-ronning@lanl.gov],
Lucas Lombriser (University of Geneva) [lucas.lombriser@unige.ch],
Georgios Loukes-Gerakopoulos (Astronomical Institute of the Czech Academy of Sciences) [gglukes@asu.cas.cz],
Yin-Zhe Ma (University of KwaZulu-Natal) [ma@ukzn.ac.za],
Elisa Maggio (Sapienza University of Rome) [elisa.maggio@uniroma1.it],
Michele Maggiore (University of Geneva) [michele.maggiore@unige.ch],
Maciej Maliborski (University of Vienna) [maciej.maliborski@univie.ac.at],
Ilya Mandel (Monash University, Australia) [ilya.mandel@monash.edu],
Vuk Mandić (University of Minnesota Twin Cities) [vuk@umn.edu],
Charalampos Markakis (Queen Mary University of London) [c.markakis@qmul.ac.uk],
Luca Marzola (KBFI Tallinn) [luca.marzola@cern.ch],
Andrea Maselli (Sapienza University of Rome) [andrea.maselli@roma1.infn.it],
Simone Mastrogiovanni (University of Paris, CNRS, Astroparticles and Cosmology) [mastrosi@apc.in2p3.fr],
Sabino Matarrese (University of Padova and INFN Sezione di Padova, Italy) [sabino.matarrese@pd.infn.it],
Lucio Mayer (University of Zürich, Switzerland) [lmayer@physik.uzh.ch],
Anupam Mazumdar (University of Groningen) [anupam.mazumdar@rug.nl],
Sean McGee (University of Birmingham) [smcgee@star.sr.bham.ac.uk],
Eugenio Megías (University of Granada, Spain) [emegias@ugr.es],
Joel Meyers (Southern Methodist University) [jrmeyers@smu.edu],
Jurgen Mifsud (University of Malta) [jurgen.mifsud@um.edu.mt],
Deyan Mihaylov (Max Planck Institute for Gravitational Physics) [deyan.mihaylov@aei.mpg.de],
Andrew Miller (Université catholique de Louvain) [andrew.miller@uclouvain.be],
Cole Miller (University of Maryland) [miller@astro.umd.edu],
Milan Milošević (Faculty of Sciences and Mathematics, University of Niš, Serbia) [mmilan@seenet-mtp.info],
Masato Minamitsuji (Instituto Superior Técnico, Lisbon) [masato.minamitsuji@tecnico.ulisboa.pt],
Josué Molina (Escuela Agrícola Panamericana, San Antonio de Oriente, Honduras) [jmolina@zamorano.edu],
Carmen Molina-París (School of Mathematics, University of Leeds, UK) [carmen@maths.leeds.ac.uk],
David F. Mota (University of Oslo) [d.f.mota@astro.uio.no],
Suvodip Mukherjee (University of Amsterdam) [s.mukherjee@uva.nl],
Ilia Musco (IGFAE, University of Santiago de Compostela) [iliamusco@gmail.com],
Hiroyuki Nakano (Ryukoku University) [hinakano@law.ryukoku.ac.jp],
Theodoros Nakas (University of Ioannina) [t.nakas@uoi.gr],
Sourabh Nampalliwar (University of Tuebingen) [sourabh.nampalliwar@uni-tuebingen.de],
Germano Nardini (University of Stavanger) [germano.nardini@uis.no],
Pavel Naselsky (Niels Bohr Institute, University of Copenhagen) [naselsky@nbi.dk],
Petya Nedkova (University of Sofia) [pnedkova@phys.uni-sofia.bg],
David Neilsen (Brigham Young University) [david.neilsen@byu.edu],
Kenny C. Y. Ng (The Chinese University of Hong Kong) [kcyng@phy.cuhk.edu.hk],
Ken K. Y. Ng (Massachusetts Institute of Technology) [kenkyng@mit.edu],
David Nichols (University of Virginia) [david.nichols@virginia.edu],

Nils A. Nilsson (National Centre for Nuclear Research, Warsaw, Poland) [albin.nilsson@ncbj.gov.pl],
Viviana Niro (Université de Paris, CNRS, Astroparticule et Cosmologie) [viviana.niro@apc.in2p3.fr],
Samaya Nissanke (University of Amsterdam) [samaya.nissanke@uva.nl],
Jose Miguel No (Universidad Autónoma de Madrid, Spain) [josemiguel.no@uam.es],
Colin A. Norman (Johns Hopkins University & Space Telescope Science Institute) [cnorman3@jhu.edu],
Roberto Oliveri (CEICO, Institute of Physics of the Czech Academy of Sciences) [roliveri@fzu.cz],
Giorgio Orlando (University of Padova) [giorgio.orlando@phd.unipd.it],
Richard O'Shaughnessy (Rochester Institute of Technology) [rossma@rit.edu],
Fabio Pacucci (Harvard University and SAO, United States) [fabio.pacucci@cfa.harvard.edu],
Antonella Palmese (Fermi National Accelerator Laboratory) [palmese@fnal.gov],
Cristiano Palomba (INFN Roma, Italy) [cristiano.palomba@roma1.infn.it],
Paolo Pani (Sapienza University of Rome) [paolo.pani@uniroma1.it],
Francesco Pannarale (Sapienza University of Rome) [francesco.pannarale@uniroma1.it],
George Pappas (Aristotle University of Thessaloniki) [gpappas@auth.gr],
Sohyun Park (CERN) [sohyun.park@cern.ch],
Vasileios Paschalidis (University of Arizona) [vpaschal@email.arizona.edu],
Vedad Pasic (University of Tuzla) [vedad.pasic@untz.ba],
Hiranya V. Peiris (UCL, Oskar Klein Centre Stockholm) [h.peiris@ucl.ac.uk],
Valeria Pettorino (AIM, CEA, CNRS, Université Paris-Saclay, Université de Paris) [valeria.pettorino@cea.fr],
Ornella Juliana Piccinni (INFN Sezione di Roma) [ornella.juliana.piccinni@roma1.infn.it],
Włodzimierz Piechocki (National Centre for Nuclear Research) [wlodzimierz.piechocki@ncbj.gov.pl],
Mathias Pierre (Universidad Autónoma de Madrid, Spain) [mathias.pierre@uam.es],
Lorenzo Pizzuti (Osservatorio Astronomico della Regione Autonoma Valle d'Aosta) [pizzuti@oavda.it],
Josef Pradler (Institute of High Energy Physics, Vienna) [josef.pradler@oeaw.ac.at],
Geraint Pratten (University of Birmingham) [g.pratten@bham.ac.uk],
John Quenby (Imperial College) [j.quenby@imperial.ac.uk],
Alvise Raccanelli (CERN) [alvise.raccanelli@cern.ch],
Martti Raidal (NICPB, Tallinn, Estonia) [martti.raidal@cern.ch],
Nemanja Rakić (University of Banja Luka) [nemanja.rakic@pmf.unibl.org],
Lisa Randall (Harvard University) [randall@g.harvard.edu],
Anupam Ray (Tata Institute of Fundamental Research) [anupam.ray@theory.tifr.res.in],
Vivien Raymond (Cardiff University) [raymondv@cardiff.ac.uk],
Sébastien Renaux-Petel (Institut d'Astrophysique de Paris) [renaux@iap.fr],
Angelo Ricciardone (INFN Sezione di Padova and University of Padova, Italy) [angelo.ricciardone@pd.infn.it],
Antonio Riotto (University of Geneva) [Antonio.Riotto@unige.ch],
Jorge Rocha (ISCTE – University Institute of Lisbon) [jorge.miguel.rocha@iscte-iul.pt],
Marek Rogatko (Maria Curie Sklodowska University, Lublin, Poland) [rogat@kft.umcs.lublin.pl],
Marco Roncadelli (INFN, Pavia, Italy) [marcoroncadelli@gmail.com],
Dorota Rosinska (University of Warsaw, Poland) [drosinska@astrouw.edu.pl],
Stephan Rosswog (Stockholm University, Sweden) [stephan.rosswog@astro.su.se],
Diego Rubiera-Garcia (Complutense University of Madrid) [drubiera@ucm.es],
Javier Rubio (Helsinki Institute of Physics) [javier.rubio@helsinki.fi],
Milton Ruiz (University of Illinois at Urbana-Champaign) [ruizm@illinois.edu],
Ester Ruiz Morales (Universidad Politécnica de Madrid) [ester.ruiz.morales@upm.es],
Laura Sagunski (RWTH Aachen University) [laura.sagunski@physik.rwth-aachen.de],
Mairi Sakellariadou (King's College London) [mairi.sakellariadou@kcl.ac.uk],
Jeremy Sakstein (University of Hawaii at Manoa) [sakstein@hawaii.edu],
Ippocratis D. Saltas (CEICO, Institute of Physics, Prague) [saltas@fzu.cz],

Zeyd Sam (University of Southampton) [z.sam@soton.ac.uk],
Anuradha Samajdar (Nikhef & Utrecht University) [a.samajdar@nikhef.nl],
Eusebio Sánchez (CIEMAT, Madrid) [eusebio.sanchez@ciemat.es],
Nicolas Sanchis-Gual (Instituto Superior Técnico, Lisbon) [nicolas.sanchis@tecnico.ulisboa.pt],
Laura Sberna (Perimeter Institute for Theoretical Physics, Canada) [lsberna@perimeterinstitute.ca],
Patricia Schmidt (University of Birmingham) [pschmidt@star.sr.bham.ac.uk],
Kai Schmitz (CERN) [kai.schmitz@cern.ch],
Pedro Schwaller (Mainz University) [pedro.schwaller@uni-mainz.de],
Ali Seraj (Université Libre de Bruxelles) [aseraj@ulb.ac.be],
Olga Sergijenko (Taras Shevchenko National University of Kyiv) [olga.sergijenko.astro@gmail.com],
Alberto Sesana (Univeristá di Milano-Bicocca, Italy) [alberto.sesana@unimib.it],
Lijing Shao (Peking University) [lshao@pku.edu.cn],
Deirdre Shoemaker (University of Texas at Austin) [deirdre@austin.utexas.edu],
Joseph Silk (Institut d'Astrophysique and The Johns Hopkins University) [silk@iap.fr],
Alicia M. Sintes (University of the Balearic Islands) [alicia.sintes@uib.es],
Carlos F. Sopuerta (Institute of Space Sciences, CSIC and IEEC) [sopuerta@ice.csic.es],
Lorenzo Sorbo (University of Massachusetts, Amherst) [sorbo@physics.umass.edu],
Thomas P. Sotiriou (University of Nottingham) [Thomas.Sotiriou@nottingham.ac.uk],
Ulrich Sperhake (University of Cambridge) [U.Sperhake@damtp.cam.ac.uk],
Leo Stein (University of Mississippi) [lcstein@olemiss.edu],
Danièle Steer (University of Paris) [steer@apc.univ-paris7.fr],
Nikolaos Stergioulas (Aristotle University of Thessaloniki) [niksterg@auth.gr],
Isabel Suárez Fernández (Instituto Superior Técnico, Lisbon) [isabel.suarez@tecnico.ulisboa.pt],
Ling Sun (California Institute of Technology & Australian National University) [ling.sun@anu.edu.au],
Patrick J. Sutton (Cardiff University) [suttonpj1@cardiff.ac.uk],
Arthur G. Suvorov (University of Tübingen) [arthur.suvorov@tat.uni-tuebingen.de],
Tayebeh Tahamtan (Charles University, Prague) [ttahamtan5@gmail.com],
Nicola Tamanini (Max Planck Institute for Gravitational Physics) [nicola.tamanini@aei.mpg.de],
Tomas Tamfal (University of Zurich) [tomas.tamfal@uzh.ch],
Volodymyr Takhistov (University of California, Los Angeles) [vtakhist@physics.ucla.edu],
Gianmassimo Tasinato (Swansea University, UK) [g.tasinato2208@gmail.com],
Marika Taylor (University of Southampton, UK) [m.m.taylor@soton.ac.uk],
Mark Trodden (University of Pennsylvania) [trodden@physics.upenn.edu],
Yu-Dai Tsai (Fermilab) [ytsai@fnal.gov],
Sergey Tsygankov (University of Turku) [sertsy@utu.fi],
Cora Uhlemann (Newcastle University) [cora.uhlemann@newcastle.ac.uk],
Caner Unal (CEICO, Institute of Physics of Czech Academy of Sciences) [unalx005@umn.edu],
Federico Urban (CEICO, Institute of Physics, Prague) [federico.urban@fzu.cz],
Elias C. Vagenas (Kuwait University) [elias.vagenas@ku.edu.kw],
Maarten van de Meent (Max Planck Institute for Gravitational Physics) [mmeent@aei.mpg.de],
Ville Vaskonen (King's College London) [ville.vaskonen@kcl.ac.uk],
Hardi Veermäe (NICPB, Tallinn) [hardi.veermae@cern.ch],
José Velhinho (Universidade da Beira Interior) [jvelhi@ubi.pt],
Daniele Vernieri (University of Naples "Federico II", Italy) [daniele.vernieri@unina.it],
Filippo Vernizzi (Institut de Physique Théorique, CEA Saclay) [filippo.vernizzi@ipht.fr],
Rodrigo Vicente (Instituto Superior Técnico, Lisbon) [rodrigoluisvicente@tecnico.ulisboa.pt],
Matteo Viel (SISSA, Italy) [viel@sissa.it],
Vincenzo Vitagliano (IFAE, Barcelona) [vvitagliano@ifae.es],

Luca Visinelli (University of Amsterdam) [l.visinelli@uva.nl],
Salvatore Vitale (MIT) [svitale@mit.edu],
Devin G. E. Walker (Dartmouth College) [devin.g.walker@dartmouth.edu],
Benjamin D. Wandelt (Sorbonne University) [bwandelt@iap.fr],
Barry Wardell (University College Dublin) [barry.wardell@ucd.ie],
Alan J. Weinstein (Caltech) [ajw@caltech.edu],
Amanda Weltman (University of Cape Town) [amanda.weltman@uct.ac.za],
Karl Wette (Australian National University) [karl.wette@anu.edu.au],
Graham White (IPMU) [graham.white@ipmu.jp],
Bernard Whiting (University of Florida) [bernard@phys.ufl.edu],
Helvi Witek (University of Illinois at Urbana-Champaign) [hwitek@illinois.edu],
Vojtěch Witzany (University College Dublin) [vojtech.witzany at ucd.ie],
Aneta Wojnar (University of Tartu) [aneta.magdalena.wojnar@ut.ee],
Kaze W. K. Wong (Johns Hopkins University) [kazewong@jhu.edu],
Kent Yagi (University of Virginia) [ky5t@virginia.edu],
Kadri Yakut (University of Ege) [kadri.yakut@ege.edu.tr],
Huan Yang (University of Guelph) [hyang10@uoguelph.ca],
Stoytcho Yazadjiev (University of Sofia) [yazad@phys.uni-sofia.bg],
Silvia Zane (Mullard Science Space Laboratory, University College London, UK) [s.zane@ucl.ac.uk],
Carlo Zanoni (European Southern Observatory) [carlo.zanoni@alumni.unitn.it],
Miguel Zilhão (Instituto Superior Técnico, Lisbon) [miguel.zilhao.nogueira@tecnico.ulisboa.pt],
Aaron Zimmerman (University of Texas at Austin) [aaron.zimmerman@utexas.edu],
Miguel Zumalacarregui (Max Planck Institute for Gravitational Physics) [miguel.zumalacarregui@aei.mpg.de]