

- For quantum non-demolition measurements see Caves, Thorne, Drever, Sandberg and Zimmermann (1980) and Braginsky and Kalili (1992). For application to advanced interferometers see Kimble, Levin, Matsko, Thorne and Vyatchanin (2000) and Buonanno and Chen (2001a, 2001b, 2002). For a review of quantum noise in GW interferometers see Corbitt and Mavalvala (2004).
- The effect of seismic noise in GW interferometers is discussed in Saulson (1994), Chapter 8. Newtonian noise are studied in Saulson (1984) and Beccaria *et al.* (1998). Our discussion of thermal noise followed the internal VIRGO note Flaminio *et al.* (2005), where calculations of the various thermal noise are performed in detail. Thermo-elastic noise is discussed in Braginsky and Vyatchanin (2003).
- Updated information on the existing GW inter-

ferometers, as well as technical documents, PhD theses, etc. can be found at
<http://www.ligo.caltech.edu/> (LIGO)
<http://www.cascina.virgo.infn.it/> (VIRGO)
<http://www.geo600.uni-hannover.de/> (GEO600)
<http://tamago.mtk.nao.ac.jp/> (TAMA)

- A detailed description of the LISA mission can be found in the LISA Pre-Phase A Report (1998). See also the reviews Bender (2001), Danzmann and Rüdiger (2003), and the web site <http://lisa.jpl.nasa.gov>.
- For lack of space, we have not discussed experiments searching for GWs using the Doppler tracking of spacecraft. For a recent review, see Armstrong (2006).

Bibliography

- Abbott, B. *et al.* [LIGO Science Community, LSC] (2004a). *Phys. Rev. D* **69**, 082004.
 Abbott, B. *et al.* [LSC] (2004b). *Phys. Rev. D* **69**, 102001.
 Abbott, B. *et al.* [LSC] (2004c). *Phys. Rev. D* **69**, 122001.
 Abbott, B. *et al.* [LSC] (2004d). *Phys. Rev. D* **69**, 122004.
 Abbott B. *et al.* [LSC] (2005a). *Phys. Rev. D* **72**, 082001.
 Abbott, B. *et al.* [LSC] (2005b). *Phys. Rev. Lett.* **94**, 181103.
 Abbott, B. *et al.* [LSC] (2005c). *Phys. Rev. Lett.* **95**, 221101.
 Abramowitz, M. and I. A. Stegun (1972). *Handbook of Mathematical Functions*, Dover, New York.
 Aguiar, O. D. *et al.* (2004). *Class. Quant. Grav.* **21**, S457.
 Allen, Z. A. *et al.* [IGEC] (2000). *Phys. Rev. Lett.* **85**, 5046.
 Allen, B. and J. D. Romano (1999). *Phys. Rev. D* **59**, 102001.
 Anderson, W. G. and R. Balasubramanian (1999). *Phys. Rev. D* **60**, 102001.
 Anderson, W. G., P. R. Brady, J. D. E. Creighton and E. E. Flanagan (2001). *Phys. Rev. D* **63**, 042003.
 de Andrade, V. C., L. Blanchet and G. Faye (2001). *Class. Quant. Grav.* **18**, 753.
 Apostolatos, T. A., C. Cutler, G. J. Sussman and K. S. Thorne (1994). *Phys. Rev. D* **49**, 6274.
 Arnaud, N. *et al.* (2005). *Nucl. Instr. Meth. A* **550**, 467.
 Arnowitt, R., S. Deser and C. W. Misner (1961). *Phys. Rev.* **121**, 1556.
 Arkani-Hamed, N., H. Georgi and M. D. Schwartz (2003). *Ann. Phys.* **305**, 96.
 Arkani-Hamed, N., H. C. Cheng, M. A. Luty and S. Mukohyama (2004). *JHEP* **0405**, 074.
 Armstrong, J. W. (2006). *Living Rev. Relativity* **9**, 1. Online article <http://www.livingreviews.org/lrr-2006-1>.
 Arun, K. G., L. Blanchet, B. R. Iyer and M. S. Qusailah (2004). *Class. Quant. Grav.* **21**, 3771. [Erratum-ibid. **22**, (2005) 3115].
 Ashby, N. and J. Dreitlein (1975). *Phys. Rev. D* **12**, 336.
 Astone, P., *et al.* [ROG] (1997b). *Astroparticle Phys.* **7**, 231.
 Astone, P., *et al.* [ROG] (2002). *Phys. Rev. D* **65**, 022001.
 Astone, P., *et al.* [IGEC] (2003a). *Phys. Rev. D* **68**, 022001.
 Astone, P., *et al.* [IGEC-2] (2007). arXiv:0705.0688[gr-qc].
 Astone, P., *et al.* [ROG] (2003b). *Phys. Rev. Lett.* **91**, 111101.
 Backer, D. C. and R. W. Hellings (1986). *Ann. Rev. Astron. Astrophys.*

- 24**, 537.
- Bardeen, J. M. and W. H. Press (1973). *J. Math. Phys.* **14**, 7.
- Bassan, M. (2002). In *Proceeding of the 15th International Conference on General Relativity and Gravitation*, M. Francaviglia ed., World Scientific, Singapore.
- Beccaria, M. *et al.* (1998). *Class. Quant. Grav.* **15**, 3339.
- Belczynski, K., R. E. Taam, V. Kalogera, F. A. Rasio and T. Bulik (2006). arXiv:astro-ph/0612032.
- Bender, P. L. (2001). In *Gravitational Waves*, I. Ciufolini *et al.* eds, IoP Publishing, Bristol.
- van den Berg, J. C. ed. (1999). *Wavelets in Physics*. Cambridge University Press, Cambridge.
- Bertotti, B. and A. M. Anile (1973). *Astron. Astrophys.* **28**, 429.
- Bianchi, M., E. Coccia, C. N. Colacino, V. Fafone and F. Fucito (1996). *Class. Quant. Grav.* **13**, 2865.
- Bianchi, M., M. Brunetti, E. Coccia, F. Fucito, and J. A. Lobo (1998). *Phys. Rev. D* **57**, 4525.
- Binney, J. and M. Merrifield (1998). *Galactic Astronomy*. Princeton University Press, Princeton.
- Binney, J. and S. Tremaine (1994). *Galactic Dynamics*. Princeton University Press, Princeton.
- Black E. D. (2001). *Am. J. Phys.* **69**, 79.
- Black E. D. and R. N. Gutenkunst (2003). *Am. J. Phys.* **71**, 365.
- Blair, D., *et al.* (1995). *Phys. Rev. Lett.* **74**, 1908.
- Blanford, R. D. and S. A. Teukolsky (1976). *Astrophys. J.* **205**, 580.
- Blanchet, L. (1987). *Proc. Roy. Soc. Lond. A* **409**, 383.
- Blanchet, L. (1993). *Phys. Rev. D* **47**, 4392.
- Blanchet, L. (1995). *Phys. Rev. D* **51**, 2559.
- Blanchet, L. (1996). *Phys. Rev. D* **54**, 1417.
- Blanchet, L. (1997). *Phys. Rev. D* **55**, 714.
- Blanchet, L. (1998a). *Class. Quant. Grav.* **15**, 89.
- Blanchet, L. (1998b). *Class. Quant. Grav.* **15**, 113.
- Blanchet, L. (1998c). *Class. Quant. Grav.* **15**, 1971.
- Blanchet, L. (2006). *Living Rev. Relativity* **9**, 4. Online article <http://www.livingreviews.org/lrr-2006-4>.
- Blanchet, L. and T. Damour (1986). *Phil. Trans. R. Soc. London A* **320**, 379.
- Blanchet, L. and T. Damour (1988). *Phys. Rev. D* **37**, 1410.
- Blanchet, L. and T. Damour (1989). *Ann. Inst. H. Poincaré* **50**, 377.
- Blanchet, L. and G. Schäfer (1989). *Mon. Not. R. Astron. Soc.* **239**, 845.
- Blanchet, L. and T. Damour (1992). *Phys. Rev. D* **46**, 4304.
- Blanchet, L. and G. Schäfer (1993). *Class. Quant. Grav.* **10**, 2699.
- Blanchet, L., T. Damour and B. R. Iyer (1995). *Phys. Rev. D* **51**, 5360. [Erratum-ibid. *D* **54**, (1996) 1860].
- Blanchet, L. and B. S. Sathyaprakash (1995). *Phys. Rev. Lett.* **74**, 1067.
- Blanchet, L., B. R. Iyer, C. M. Will and A. G. Wiseman (1996). *Class. Quant. Grav.* **13**, 575.

- Blanchet, L., G. Faye and B. Ponsot (1998). *Phys. Rev. D* **58**, 124002.
- Blanchet, L. and G. Faye (2001). *Phys. Rev. D* **63**, 062005.
- Blanchet, L., B. R. Iyer and B. Joguet (2002). *Phys. Rev. D* **65**, 064005. [Erratum-ibid. *D* **71**, 129903 (2005)]
- Blanchet, L., G. Faye, B. R. Iyer and B. Joguet (2002). *Phys. Rev. D* **65**, 061501. [Erratum-ibid. *D* **71**, 129902 (2005)].
- Blanchet, L. and B. R. Iyer (2003). *Class. Quant. Grav.* **20**, 755.
- Blanchet, L., T. Damour and G. Esposito-Farèse (2004). *Phys. Rev. D* **69**, 124007.
- Blanchet, L., T. Damour, G. Esposito-Farèse and B. R. Iyer (2004). *Phys. Rev. Lett.* **93**, 091101.
- Blanchet, L., T. Damour, G. Esposito-Farèse and B. R. Iyer (2005). *Phys. Rev. D* **71**, 124004.
- Blanchet, L., G. Faye, and S. Nissanke (2005). *Phys. Rev. D* **72**, 044024.
- Blanchet, L., A. Buonanno and G. Faye (2006). *Phys. Rev. D* **74**, 104034.
- Bonazzola, S. and E. Gourgoulhon (1996). *Astron. Astrophys.* **312**, 675.
- Bondarescu, M. and K. S. Thorne (2006). *Phys. Rev. D* **74**, 082003.
- Bondi, H., M. G. J. van der Burg and A. K. W. Metzner (1962). *Proc. Roy. Soc. London A* **269**, 21.
- Bondu, F. (2003). VIRGO internal note VIR-NOT-OCA-1390-243, unpublished.
- Bontz R.J. and M.P. Haugan (1981). *Astrophysics and Space Science* **78**, 199.
- Boulware, D. G. and S. Deser (1972). *Phys. Rev. D* **6**, 3368.
- Brady, P. R., T. Creighton, C. Cutler and B. F. Schutz (1998). *Phys. Rev. D* **57**, 2101.
- Brady, P. R. and T. Creighton (2000). *Phys. Rev. D* **61**, 082001.
- Braginsky, V. B. and L. P. Grishchuk (1986). *Sov. Phys. JETP* **62**, 427.
- Braginsky, V. B. and K. S. Thorne (1987). *Nature* **327**, 123.
- Braginsky, V. B. and F. Ya. Kalili (1992). *Quantum Measurement*. Cambridge University Press, Cambridge.
- Braginsky, V. B. and S. P. Vyatchanin (2003). *Phys. Lett. A* **312**, 244.
- Briant, T., *et al.* (2003). *Phys. Rev. D* **67**, 102005.
- Bruhat, Y. (1962). In *Gravitation: An Introduction to Current Research*, L. Witten ed., Wiley, New York.
- Buonanno, A. and Y. B. Chen (2001a). *Phys. Rev. D* **64**, 042006.
- Buonanno, A. and Y. B. Chen (2001b). *Class. Quant. Grav.* **18**, L95.
- Buonanno, A. and Y. B. Chen (2002). *Phys. Rev. D* **65**, 042001.
- Buonanno, A., Y. B. Chen and M. Vallisneri, (2003). *Phys. Rev. D* **67**, 024016.
- Burgay, M. *et al.* (2003). *Nature*, **426**, 531.
- Burke, W. L. (1971). *J. Math. Phys.* **12**, 401.
- Caves, C. M. (1980). *Phys. Rev. Lett.* **45**, 75.
- Caves, C. M. (1981). *Phys. Rev. D* **23**, 1693.
- Caves, C. M., K. S. Thorne, R. W. P. Drever, V. D. Sandberg, and M. Zimmermann (1980). *Rev. Mod. Phys.* **52**, 341.
- Cerdonio, M. *et al.* [AURIGA] (1997). *Class. Quant. Grav.* **14**, 1491.

- Cerdonio, M., L. Conti, J. A. Lobo, A. Ortolan and J. P. Zendri (2001). *Phys. Rev. Lett.* **87**, 031101.
- Cerdonio, M. (2003). *Class. Quant. Grav.* **20**, S23.
- Chandrasekhar, S. (1969). *Ellipsoidal Figures of Equilibrium*. Yale University Press, New Haven.
- Chandrasekhar, S. and F. P. Esposito (1970). *Astrophys. J.* **160**, 153.
- Christensen, N. (1992). *Phys. Rev. D* **46**, 5250.
- Christodoulou, D. (1991). *Phys. Rev. Lett.* **67**, 1486.
- Christodoulou, D. and S. Klainerman (1993). *The global nonlinear stability of the Minkowski space*. Princeton University Press, Princeton.
- Clark, J.P.A. and D. M. Eardley (1977). *Astrophys. J.* **215**, 315.
- Coccia, E. (1997). In *Proceeding of the 14th International Conference on General Relativity and Gravitation*, M. Francaviglia ed., World Scientific, Singapore.
- Coccia, E., J. A. Lobo, and J. A. Ortega (1995). *Phys. Rev. D* **52**, 3735.
- Coccia, E. and V. Fafone (1996). *Phys. Lett. A* **213**, 16.
- Coccia, E., V. Fafone, G. Frossati, J. A. Lobo and J. A. Ortega (1998). *Phys. Rev. D* **57**, 2051.
- Coccia, E., F. Dubath and M. Maggiore (2004). *Phys. Rev. D* **70**, 084010.
- Corbitt, T. and N. Mavalvala (2004). *J. Opt. B* **6**, S675.
- Cousins, R. D. (1995). *Am. J. Phys.* **63**, 398.
- Creminelli, P., A. Nicolis, M. Papucci and E. Trincherini (2005). *JHEP* **0509**, 003.
- Cutler, C. et al. (1993). *Phys. Rev. Lett.* **70**, 2984.
- Cutler, C. and E. E. Flanagan (1994). *Phys. Rev. D* **49**, 2658.
- Cutler, C. and D. I. Jones (2001). *Phys. Rev. D* **63**, 024002.
- van Dam, H. and M. Veltman (1970). *Nucl. Phys. B* **22**, 397.
- Damour, T. (1983a). *Phys. Rev. Lett.* **51**, 1019.
- Damour, T. (1983b). In *Gravitational Radiation*, N. Deruelle and T. Piran eds., Les Houches 1982, North-Holland, Amsterdam.
- Damour, T. (1986). In *Proceedings of the 4th Marcel Grossmann Meeting on General Relativity* ed R. Ruffini, North-Holland, Amsterdam.
- Damour, T. (1987). In *300 Years of Gravitation*, S. Hawking and W. Israel eds., Cambridge University Press, Cambridge.
- Damour, T. and N. Deruelle (1981). *Phys. Lett. A* **87**, 81.
- Damour, T. and N. Deruelle (1985). *Ann. Inst. H. Poincaré* **43**, 107.
- Damour, T. and N. Deruelle (1986). *Ann. Inst. H. Poincaré* **44**, 263.
- Damour, T. and G. Schäfer (1988). *Nuovo Cimento B*, **101**, 127.
- Damour, T. and B. R. Iyer (1991a). *Phys. Rev. D* **43**, 3259.
- Damour, T. and B. R. Iyer (1991b). *Ann. Inst. H. Poincaré* **54**, 115.
- Damour, T. and J. H. Taylor (1991). *Astrophys. J.* **366**, 501.
- Damour, T. and J. H. Taylor (1992). *Phys. Rev. D* **45**, 1840.
- Damour, T., P. Jaranowski and G. Schäfer (2000). *Phys. Rev. D* **62**, 021501. [Erratum-ibid. *D* **63**, (2001) 029903].
- Damour, T., P. Jaranowski and G. Schäfer (2001a). *Phys. Rev. D* **63**, 044021. [Erratum-ibid. *D* **66**, (2002) 029901].
- Damour, T., P. Jaranowski and G. Schäfer (2001b). *Phys. Lett.* **513**, 147.
- Damour, T., B. R. Iyer and B. S. Sathyaprakash (2001). *Phys. Rev. D* **63**, 044023. [Erratum-ibid. *D* **72** (2005) 029902].
- Damour, T., I. I. Kogan and A. Papazoglou (2003). *Phys. Rev. D* **67**, 064009.
- Damour, T., A. Gopakumar and B. R. Iyer (2004). *Phys. Rev. D* **70**, 064028.
- Danzmann, K. and A. Rüdiger (2003). *Class. Quant. Grav.* **20**, S1.
- Davies, M. R., R. Ruffini, W. H. Press and R.H. Price (1971). *Phys. Rev. Lett.* **27**, 1466.
- Davies, M. R., R. Ruffini and J. Tiomno (1972). *Phys. Rev. D* **5**, 2932.
- Deffayet, C., G. R. Dvali, G. Gabadadze and A. I. Vainshtein (2002). *Phys. Rev. D* **65**, 044026.
- Detweiler, S. L. and E. Szedenits (1979). *Astrophys. J.* **231**, 211.
- Deser, S. (1970). *Gen. Relativ. Gravit.* **1**, 9.
- DeWitt, B. S. (1967). *Phys. Rev.* **162**, 1239.
- Drever, R. W. P. (1991). In *The Detection of Gravitational Waves*, D. G. Blair ed., Cambridge University Press, Cambridge.
- Dubath, F., S. Foffa, M. A. Gasparini, M. Maggiore and R. Sturani (2005). *Phys. Rev. D* **71**, 124003.
- Dubovski, S.L., P. G. Tinyakov and I. I. Tkachev (2005). *Phys. Rev. Lett.* **94**, 181102.
- Edelstein, W. A., J. Hough, J. R. Pugh and W. Martin (1978). *J. Phys. E* **11**, 710.
- Ehlers, J., A. Rosenblum, J. N. Goldberg and P. Havas (1976). *Astrophys. J.* **208**, L77.
- Einstein, A., L. Infeld and B. Hoffmann (1938). *Ann. Math.* **39**, 65.
- Epstein, R. (1977). *Astrophys. J.* **216**, 92.
- Epstein, R. (1979). *Astrophys. J.* **231**, 644.
- Epstein, R. and R. V. Wagoner (1975). *Astrophys. J.* **197**, 717.
- Faye, G., L. Blanchet and A. Buonanno (2006). *Phys. Rev. D* **74**, 104033.
- Feldman G. J. and R. D. Cousins (1998). *Phys. Rev. D* **57**, 3873.
- Feynman, R. P., F. B. Morinigo, and W. G. Wagner (1995). *Feynman Lectures on Gravitation*, Addison-Wesley, Reading, MA.
- Finn, S. L. (1992). *Phys. Rev. D* **46**, 5236.
- Finn, S. L. and D. F. Chernoff (1993). *Phys. Rev. D* **47**, 2198.
- Finn, S. L. and A. Lazzarini (2001). *Phys. Rev. D* **64**, 082002.
- Finn, S. L. and P. J. Sutton (2002). *Phys. Rev. D* **65**, 044022.
- Flaminio, R. et al. (2005). Internal VIRGO note VIR-NOT-DIR-1390-304, unpublished.
- Flanagan, E. E. (1993). *Phys. Rev. D* **48**, 2389.
- Flanagan, E. E. and S. A. Hughes (1998a). *Phys. Rev. D* **57**, 4535.
- Flanagan, E. E. and S. A. Hughes (1998b). *Phys. Rev. D* **57**, 4566.
- Forward, R. (1971). *Gen. Relativ. Gravit.* **2**, 149.
- Giazotto, A. (1989). *Phys. Rept.* **182**, 365.
- Gottardi, L. (2004). *Transducers and low-noise two-stage SQUID amplifiers for the spherical gravitational wave antenna MiniGrail*. PhD

- thesis, Leiden University, Leiden, The Netherlands.
- Gibbons, G. W. and S. W. Hawking (1971). *Phys. Rev. D* **4**, 219.
- Giffard, R. P. (1976). *Phys. Rev. D* **14**, 2478.
- Goldhaber, A. S. and Nieto, M. M. (1974). *Phys. Rev. D* **9**, 1119.
- Goldberger, W. D. and I. Z. Rothstein (2006). *Phys. Rev. D* **73**, 104029.
- Gopakumar, A., B. R. Iyer and S. Iyer (1997). *Phys. Rev. D* **55**, 6030.
- Gopakumar, A. and B. R. Iyer (2002). *Phys. Rev. D* **65**, 084011.
- Gradshteyn I. S. and Ryzhik, I. M. (1980). *Table of Integrals, Series and Products*. Academic Press, London.
- Grisaru, M. T., P. van Nieuwenhuizen, and C. C. Wu (1975). *Phys. Rev. D* **12**, 397.
- Gupta S. N. (1954). *Phys. Rev.* **96**, 1683.
- Gürsel, Y. and M. Tinto (1989). *Phys. Rev. D* **40**, 3884.
- Hamermesh, M. (1962). *Group Theory*. Addison-Wesley, Redwood.
- Hartle, J. B. (2003). *Gravity. An Introduction to Einstein's General Relativity*. Addison Wesley, San Francisco.
- Haugan, M. P. (1985). *Astrophys. J.* **296**, 1.
- Haugan, M. P., S. L. Shapiro, and I. Wasserman (1982). *Astrophys. J.* **257**, 283.
- Hulse, R. A. (1994) *Rev. Mod. Phys.* **66**, 699.
- Hulse, R. A. and J. H. Taylor (1975). *Astrophys. J.* **195**, L51.
- Isaacson, R. A. (1968a). *Phys. Rev.* **166**, 1263.
- Isaacson, R. A. (1968b). *Phys. Rev.* **166**, 1272.
- Iwasaki, Y. (1970). *Phys. Rev. D* **2**, 2255.
- Iyer, B. R. and C. M. Will (1993). *Phys. Rev. Lett.* **70**, 113.
- Iyer, B. R. and C. M. Will (1995). *Phys. Rev. D* **52**, 6882.
- Itoh, Y. (2004). *Phys. Rev. D* **69**, 064018.
- Itoh, Y., Futamase, T. and Asada, H. (2000). *Phys. Rev. D* **62**, 064002.
- Itoh, Y., Futamase, T. and Asada, H. (2001). *Phys. Rev. D* **63**, 064038.
- Itoh, Y. and Futamase, T. (2003). *Phys. Rev. D* **68**, 121501(R).
- Jackson, J. D. (1975). *Classical Electrodynamics*. Wiley, Chichester.
- Jackson, J. D. and L. B. Okun (2001). *Rev. Mod. Phys.* **73**, 663.
- Jaranowski, P. and G. Schäfer (1998). *Phys. Rev. D* **57**, 7274. [Erratum-
ibid. *D* **63** (2001) 029902].
- Jaranowski, P. and G. Schäfer (1999). *Phys. Rev. D* **60**, 124003.
- Jaranowski, P. and G. Schäfer (2000). *Ann. Phys.* **9**, 378.
- Johnson, W. W. and S. M. Merkowitz (1993). *Phys. Rev. Lett.* **70**, 2367.
- Johnson, W. W. and S. M. Merkowitz (1997). *Phys. Rev. D* **56**, 7513.
- Ju, L., D. G. Blair and C. Zhao (2000). *Rep. Prog. Phys.* **63**, 1317.
- Kennefick, D. (1994). *Phys. Rev. D* **50**, 3587.
- Kennefick, D. (1997). arXiv:gr-qc/9704002.
- Kennefick, D. (2007). *Traveling at the Speed of Thought*. Princeton University Press, Princeton.
- Kidder, L. E. (1995). *Phys. Rev. D* **52**, 821.
- Kidder, L. E., C. M. Willand and A. G. Wiseman (1993). *Phys. Rev. D* **47**, R4183.
- Klimenko, S., I. Yakushin, M. Rakhmanov and G. Mitselmakher (2004). *Class. Quant. Grav.* **21**, S1685.
- Klimenko, S. and G. Mitselmakher (2004). *Class. Quant. Grav.* **21**, S1819.
- Kimble, H. J., Y. Levin, A. B. Matsko, K. S. Thorne and S. P. Vyatchanin (2002). *Phys. Rev. D* **65**, 022002.
- Konigsdorffer, C., G. Faye and G. Schäfer (2003). *Phys. Rev. D* **68**, 044004.
- Kolb, E. W. and M. S. Turner (1990). *The Early Universe*, Addison Wesley, Reading, MA.
- Kraichnan, R. H. (1955). *Phys. Rev.* **98**, 1118; *ibid.* **101**, 482.
- Kramer, M. et al., (2005). "Testing GR with the Double pulsar: Recent Results", astro-ph/0503386.
- Kramer, M. et al., (2006). "Tests of general relativity from timing the double pulsar" astro-ph/0609417.
- Krishnan, B. et al. (2004). *Phys. Rev. D* **70**, 082001.
- Królak, A., K. D. Kokkotas and G. Schäfer (1995). *Phys. Rev. D* **52**, 2089.
- Landau, L. D. and E. M. Lifshitz (1976). *Course of Theoretical Physics*, Vol. I: *Mechanics*. Pergamon Press, Oxford.
- Landau, L. D. and E. M. Lifshitz (1979). *Course of Theoretical Physics*, Vol. II: *The Classical Theory of Fields*. Pergamon Press, Oxford.
- Landau, L. D. and E. M. Lifshitz (1982). *Course of Theoretical Physics*, Vol. IV (by V.B. Berestetskij, E. M. Lifshitz and L. P. Pitaevskij): *Quantum Electrodynamics*. Pergamon Press, Oxford.
- Landau, L. D. and E. M. Lifshitz (1970). *Course of Theoretical Physics*, Vol. VII: *Theory of Elasticity*. Pergamon Press, Oxford.
- Larson, S. L. and W. A. Hiscock (2000). *Phys. Rev. D* **61**, 104008.
- LISA: Pre-Phase A Report, MPQ 208, Max-Planck-Institute für Quantenoptik, Garching, Germany.
- Lobo, J. A. (1995). *Phys. Rev. D* **52**, 591.
- Lobo, J. A. (2002). *Class. Quant. Grav.* **19**, 2029.
- Lorimer, D. R. (2005). Living Rev. Relativity **8**, 7. Online article <http://www.livingreviews.org/lrr-2005-7>.
- Love, A. E. H. (1944). *A Treatise on the Mathematical Theory of Elasticity*. Dover, New York.
- Lyne, A. G. et al. (2004). *Science*, **303**, 1153.
- Lyne, A. G. and F. Graham-Smith (2005). *Pulsar Astronomy*, 3rd edition, Cambridge University Press, Cambridge.
- Lyons, L. (1986). *Statistics for Nuclear and Particle Physicists*, Cambridge University Press, Cambridge.
- McDonough, R. N. and A. D. Whalen (1995). *Detection of Signals in Noise*, 2nd edition. Academic Press, San Diego.
- Maggiore, M. (2000). *Phys. Rept.* **331**, 283.
- Maggiore, M. (2005). *A Modern Introduction to Quantum Field Theory*. Oxford University Press, Oxford.
- Maggiore, M. and A. Nicolis, (2000). *Phys. Rev. D* **62**, 024004.
- Mauceli, E., et al. [ALLEGRO] (1996). *Phys. Rev. D* **54**, 1264.
- Meers, B. J. (1988). *Phys. Rev. D* **38**, 2317.

- Meers, B. J. (1989). *Phys. Lett. A* **142**, 465.
- Merkowitz, S. (1995). *Truncated icosahedral gravitational wave antenna*, PhD Thesis, Louisiana State University, available online at <http://sam.phys.lsu.edu>.
- Merkowitz, S. M. and W. W. Johnson (1995). *Phys. Rev. D* **51**, 2546.
- Michelson, P. F. (1987). *Mon. Not. R. Astron. Soc.* **227**, 933.
- Michelson, P. F. and R. C. Taber (1981). *J. Appl. Phys.* **52**, 4313.
- Michelson, P. F. and R. C. Taber (1984). *Phys. Rev. D* **29**, 2149.
- Misner, C. W., K. S. Thorne and J. A. Wheeler (1973). *Gravitation*, Freeman, New York.
- Mizuno, J. et al. (1993). *Phys. Lett. A* **175**, 273.
- Newman, E. T. and R. Penrose (1968). *Proc. Roy. Soc. London A*, **305**, 175.
- Ni, W.-T. and M. Zimmermann (1978). *Phys. Rev. D* **17**, 1473.
- Niebauer, T.M., R. Schilling, K. Danzmann, A. Rüdiger and W. Winckler (1991). *Phys. Rev. A* **43**, 5022.
- van Nieuwenhuizen, P. (1973). *Phys. Rev. D* **7**, 2300.
- Nissanke, S. and L. Blanchet (2005). *Class. Quant. Grav.* **22**, 1007.
- Ogievetsky, V. I. and I. V. Polubarinov (1965). *Ann. Phys.* **35**, 167.
- Ohanian, H. C. and R. Ruffini (1994). *Gravitation and Spacetime*. Norton, New York.
- Owen, B. J. (1996). *Phys. Rev. D* **53**, 6749.
- Owen, B. J. and B. S. Sathyaprakash (1999). *Phys. Rev. D* **60**, 022002.
- Padmanabhan, T. (2004). arXiv:gr-qc/0409089.
- Paik, H. J. (1976). *J. Appl. Phys.* **47**, 1168.
- Pallottino, G. V. and G. Pizzella (1981). *Nuovo Cim. C* **4**, 237.
- Pallottino, G. V. and G. Pizzella (1984). *Nuovo Cim. C* **7**, 155.
- Pallottino, G. V. and G. Pizzella (1991). In *The Detection of Gravitational Waves*, D. G. Blair ed., Cambridge University Press, Cambridge.
- Pati, M. E. and C. M. Will (2000). *Phys. Rev. D* **62**, 124015.
- Pati, M. E. and C. M. Will (2002). *Phys. Rev. D* **65**, 104008.
- Penrose, R. (1963). *Phys. Rev. Lett.* **10**, 66.
- Penrose, R. (1965). *Proc. Roy. Soc. London A* **284**, 159.
- Peters, P. C. (1964). *Phys. Rev.* **136**, B1224.
- Peters, P. C. and J. Mathews (1963). *Phys. Rev.* **131**, 435.
- Pirani, F. A. E. (1964). In *Lectures on General Relativity*, A. Trautman et al. eds., Prentice-Hall, Englewood Cliffs.
- Poisson, E. (1993). *Phys. Rev. D* **47**, 1497.
- Poisson, E. (1999). arXiv:gr-qc/9912045.
- Poisson, E. and C. M. Will (1995). *Phys. Rev. D* **49**, 848.
- Poujade, O. and L. Blanchet (2002). *Phys. Rev. D* **65**, 124020.
- Price, J. C. (1987). *Phys. Rev. D* **36**, 3555.
- Rendall, A. D. (1992). *Proc. Roy. Soc. London A* **438**, 341.
- Richard J.-P. and W. M. Folkner (1991). In *The Detection of Gravitational Waves*, D. G. Blair ed., Cambridge University Press, Cambridge.
- Rowan, S. and J. Hough, (2000). *Living Rev. Rel.* **3**, 3. Online article <http://www.livingreviews.org/lrr-2000-3>.
- Rubakov, V., arXiv:hep-th/0407104.
- Sachs, R. K. (1961). *Proc. Roy. Soc. London A* **264**, 309.
- Sachs, R. K. (1962). *Proc. Roy. Soc. London A* **270**, 103.
- Sasaki, M. (1994). *Prog. Theor. Phys.* **92**, 17.
- Saulson, P. R. (1984). *Phys. Rev. D* **30**, 732.
- Saulson, P. R. (1994). *Fundamentals of Interferometric Gravitational Wave Detectors*, World Scientific, Singapore.
- Schutz, B. F. (1986). *Nature*, **323**, 310.
- Schutz, B. F. (1991). In *The Detection of Gravitational Waves*, D. G. Blair ed., Cambridge University Press, Cambridge.
- Schutz, B. F. and F. Ricci (2001). In *Gravitational Waves*, I. Ciufolini et al. eds., IoP Publishing, Bristol.
- Shapiro, S.L. and S.A. Teukolsky (1983). *Black Holes, White Dwarfs and Neutron Stars*, Wiley, New York.
- Smarr, L. (1979). In *Sources of Gravitational Radiation*, ed. L. Smarr. Cambridge University Press, Cambridge.
- Spallicci, A., G. Frossati and A. Królak (1997) *Class. Quant. Grav.* **14**, 577.
- Stairs, I. H. (2003). *Living Rev. Relativity* **6**, 5. Online article <http://www.livingreviews.org/lrr-2003-5>.
- Stairs, I. H., S. E. Thorsett, J. H. Taylor and A. Wolszczan (2002). *Astrophys. J.* **581**, 501.
- Stevenson, T. R. (1997). *Phys. Rev. D* **56**, 564.
- Straumann, N. (2004). *General Relativity. With Applications to Astrophysics*. Springer, Berlin.
- Tagoshi, H. and M. Sasaki (1994). *Prog. Theor. Phys.* **92**, 745.
- Tagoshi, H., A. Ohashi and B. J. Owen (2001). *Phys. Rev. D* **63**, 044006.
- Tanaga, T., H. Tagoshi and M. Sasaki (1996). *Prog. Theor. Phys.* **96**, 1087.
- Taylor, J. H. (1994). *Rev. Mod. Phys.* **66**, 711.
- Taylor, J. H., L. A. Fowler and P. M. McCulloch (1979). *Nature* **277**, 437.
- Taylor, J. H. and J. M. Weisberg (1982). *Astrophys. J.* **253**, 908.
- Taylor, J. H. and J. M. Weisberg (1989). *Astrophys. J.* **345**, 434.
- Thorne, K. S. (1980). *Rev. Mod. Phys.* **52**, 299.
- Thorne, K. S. (1983). In *Gravitational Radiation*, N. Deruelle and T. Piran eds., Les Houches 1982, North-Holland, Amsterdam.
- Thorne, K. S. (1987). In *300 Years of Gravitation*, S. Hawking and W. Israel eds., Cambridge University Press, Cambridge.
- Thorne, K. S. (1992). *Phys. Rev. D* **45**, 520.
- Thorne, K. S. (1994). *Black Holes and Time Warps: Einstein's Outrageous Legacy*, Norton, New York.
- Thorne, K. S and Y. Gürsel (1983). *Mon. Not. R. Astron. Soc.* **205**, 809.
- Vainshtein, A. I. (1972). *Phys Lett. B* **39**, 393.
- Van Den Broeck, C. (2005). *Class. Quant. Grav.* **22**, 1825.

- Veitch P. J. (1991). In *The Detection of Gravitational Waves*, D. G. Blair ed., Cambridge University Press, Cambridge.
- Veltman, M. J. G. (1976). *Quantum Theory of Gravitation*, in *Methods in Field Theory*, Les Houches 1975, R. Balian and J. Zinn-Justin eds., North-Holland, Amsterdam.
- Viceré, A. (2000). In *Experimental Physics of Gravitational Waves*, Urbino 1999 Summer School, M. Barone *et al.* eds., World Scientific, Singapore.
- Viceré, A. (2002). *Phys. Rev. D* **66**, 062002.
- Vinet, J.-Y., B. Meers, C. N. Man and A. Brillet (1988). *Phys. Rev. D* **38**, 433.
- Vinet, J.-Y., V. Brisson and S. Braccini (1996). *Phys. Rev. D* **54**, 1276.
- Vinet, J.-Y. *et al.* (1997). *Phys. Rev. D* **56**, 6085.
- de Waard, A. (2003). *MiniGrail. The first spherical gravitational wave antenna*. PhD thesis, Leiden University, Leiden, The Netherlands.
- de Waard, A., L. Gottardi, J. van Houwelingen, A. Schumack and G. Frossati (2003). *Class. Quant. Grav.* **20**, S143.
- Wagoner, R. V. (1979). *Phys. Rev. D* **19**, 2897.
- Wagoner, R. V. and C. M. Will (1976). *Astrophys. J.* **210**, 764.
- Wagoner, R. V. and H. J. Paik (1977). In *Experimental Gravitation, Proceedings of the Pavia International Symposium*, Accademia Naz. dei Lincei, Roma.
- Wainstein, L. A. and V. D. Zubakov (1965). *Extraction of Signals from Noise*, Dover Publications, New York.
- Walker, M. and C. Will (1980a). *Phys. Rev. Lett.* **45**, 1741.
- Walker, M. and C. Will (1980b). *Astrophys. J.* **242**, L129.
- Watson, (1966). *A Treatise on the Theory of Bessel Functions*, Cambridge University Press, Cambridge.
- Weinberg, S. (1972). *Gravitation and Cosmology*. Wiley, New York.
- Weisberg, J. M. and J. H. Taylor, (2002). In Proceedings of “Binary Pulsars”, Chania, Crete 2002, APS Conference Series, M. Bailes, D. J. Nice and S.E. Thorsett eds., astro-ph/0211217.
- Weisberg, J. M. and J. H. Taylor, (2004). In Proceedings of “Aspen Winter Conference on Astrophysics: Binary Radio Pulsars”, ASP Conference Series, F. A. Rasio and I. H. Stairs eds., astro-ph/0407149.
- Will, C. M. (1984). *Ann. Phys.* **155**, 133.
- Will, C. M. (1993). *Theory and Experiment in Gravitational Physics*, Revised edition, Cambridge University Press, Cambridge.
- Will, C. M. (1998). *Phys. Rev. D* **57**, 2061.
- Will, C. M. (2005). *Phys. Rev. D* **71**, 084027.
- Will, C. M. (2006). *Living Rev. Relativity* **9**, 3. Online article <http://www.livingreviews.org/lrr-2006-3>.
- Wiseman, A. G. (1992). *Phys. Rev. D* **46**, 1517.
- Wiseman, A. G. (1993). *Phys. Rev. D* **48**, 4757.
- Wiseman, A. G. and C. M. Will (1991). *Phys. Rev. D* **44**, R2945.
- Wiseman, A. G. and C. M. Will (1996). *Phys. Rev. D* **54**, 4813.
- Wolszczan, A. (1991). *Nature*, **350**, 688.
- Yao, W.-M. *et al.*[Particle Data Group] (2006). *J. Phys. G* **33**, 1. Online version at <http://pdg.lbl.gov/>
- Zakharov, V. I. (1970). *JETP Lett.* **12**, 312.
- Zeldovich, Ya. B. and A. G. Polnarev (1974). *Sov. Astron.* **18**, 17.
- Zendri, J.-P., *et al.* [AURIGA] (2002). *Class. Quant. Grav.* **19**, 1925.
- Zhou, C. Z. and P. F. Michelson (1995). *Phys. Rev. D* **51**, 2517.
- Zimmermann, M. (1980). *Phys. Rev. D* **20**, 351.
- Zimmermann, M. and E. Szedenits (1979). *Phys. Rev. D* **21**, 891.

Index

- ACIGA, 532
Active gravitational-mass density, 138, 244
Admittance, 440
AIGO, 532
Airy pattern, 500
ALLEGRO, 413, 453, 469
Amplifier noise, 443–444
Amplifier noise temperature, 447
Angular momentum of GWs, 58–65
ASTROD, 535
AURIGA, 434, 453, 469
strain sensitivity, 454
Auto-correlation function, 338

Back-action evasion, 452
Back-action noise, 446–452
Back-reaction of GWs, 116–121, 275–279
Bayes' theorem, 347
Bayesian statistics, 346–350
BBO, 535
Bessel function J_n
integral representation, 233
Bias, 352
Binary systems, 167–199
at cosmological distances, 190–199
chirp amplitude, 169–176
cycles spent in the detector
bandwidth, 171
energy spectrum of GWs, 175
Keplerian orbits, 176
mass function, 328
Newtonian waveform, 168, 172–174
PN corrections, 289–299
PN waveform, 296–299
radiated angular momentum, 184–186
radiated power, 169, 179
time to coalescence, 171, 188
Bondi-type coordinates, 266

Burke-Thorne potential, 119, 279
Bursts
bar's sensitivity, 453–454
interferometer's sensitivity, 530
matched filtering, 361–365

Central limit theorem, 393
Chirp amplitude, 169–176
post-Newtonian, 289–299
Chirp mass, 198
accuracy of reconstruction, 392
Chopping technique, 411
Christodoulou memory, 274, 300
Circular polarization, of GWs, 159
CLIO, 534
COBE, 392
Comoving coordinates, 190
Confidence level, 348
Conformal time, 195
Counting statistics, 516
Coupling rate, 487
Covariant derivative along a curve, 14
Cross-section
resonant bars, 422, 426
resonant spheres, 465
Current quadrupole, 125–131, 164

d'Alembertian
in curved space, 195
inversion, 257
Dark fringe, 504
De Donder gauge, 6, 242, 250
Deceleration parameter, 193, 194
DECIGO, 535
Detector tensor, 336
bars, 425
interferometers, 494
Dicke radiometer, 412, 504
Diffeomorphisms, 4
Diffraction, 497–503
Dipole radiation
absent for GWs, 112

DIRE, 279–281
 Dispersion measure, 312
 Displacement noise, 524
 Doppler tracking of spacecrafts, 536
 Drag free control, 534
 Drever, R., 470
 Dual detectors, 435
 Eccentric anomaly, 177, 315
 Eccentricity, 176
 Effacement of the internal structure
 in Einstein gravity, 286–289
 in Newtonian gravity, 282–286
 Eikonal approximation, 42
 Eikonal equation, 43
 Einstein action, 4
 linearized theory, 59, 72
 Einstein angle, 45
 Einstein equations, xvii, 4
 coarse-graining, 34
 relaxed, 250–252
 Einstein parameter, 316
 Einstein tensor, 251
 Einstein–Infeld–Hoffmann
 Lagrangian, 246
 Ellipticity, of rotating body, 203
 Energy density of GWs, 36
 Energy filter, 370
 Energy flux, 37–39
 Energy localization, 57–58, 61
 Energy–momentum tensor
 electromagnetism, 56–58
 GWs, 32–39, 58–61
 improved, 57
 matter, xvii, 4
 point-like particle, 121, 245
 Equivalence principle, 15
 and radiation from accelerated
 masses, 120–121
 Estimator, 352
 Euler angles, 204
 Euler equations for rigid body, 205
 Event (definition), 337
 Excess power statistic, 365, 367
 EXPLORER, 445, 453, 469
 strain sensitivity, 454
 Fabry–Perot cavity, 480–488
 finesse, 486
 free spectral range, 485
 interaction with GWs, 489–493
 optimal coupling, 488
 storage time, 486
 False alarm probability, 359
 Feedback control systems, 513
 Feldman and Cousins construction, 349
 Fermi normal coordinates, 17
 Fisher information matrix, 356
 Fluctuation–dissipation theorem, 439
 Forward, R., 470
 Four-velocity, 14
 Fourier transform
 conventions, xvii
 discrete, 366
 windowed, 368
 Fraunhofer diffraction, 497, 499–500
 Freely falling frames, 15–17
 Frequentist coverage, 348
 Frequentist statistics, 346–350
 Fresnel diffraction, 497
 Friedmann–Robertson–Walker
 cosmology, 190–194
 Gabor transform, 368
 GEO600, 480, 528–530
 Geodesic deviation, 13–15, 23
 Geodesic equation, 13–15
 Geometric optics in curved space, 42–47
 Gertsenshtein, M., 470
 Gothic metric, 250
 Gouy phase, 501
 Graviphoton, 90
 Graviscalar, 90
 Gravitational wave absorption, 46
 Gravitational wave production
 mass in circular orbit, 158–160,
 167–189
 mass in Keplerian elliptic orbit,
 176–189
 mass in parabolic orbit, 180–181
 non-relativistic sources, 105–155
 octupole, 161–162
 oscillating mass, 156–158
 post-Newtonian sources,
 236–299
 quadrupole, 109–121, 156–160
 relativistic sources, 102–105
 Gravitational wave propagation,
 40–46
 geometric optics, 42
 Graviton, 70–95
 angular momentum states,
 98–99
 bounds on the mass, 82
 helicity, 98–99
 massive, 81–95
 non-linear couplings, 74–79
 propagator, 74
 spin, 66–70
 GRAVITON project, 469
 Gravity
 as a field theory, 66–95
 linearized, 53–65
 non-renormalizable, 79
 Green’s function, retarded, 102, 257
 GW bursters, 413
 GWIC, 469
 Gyroscopes and freely falling frame, 16
 $h_{3/\text{yr}}$, 375
 Hadamard regularization, 300
 Harmonic coordinates, 242
 Harmonic gauge, 6, 242
 Hereditary terms, in the PN
 expansion, 267–275
 Hermite–Gauss modes, 503
 Hilbert gauge, 6
 Hooke’s law, 459
 Hough transform, 385–386
 Hubble expansion rate, 193, 194, 395
 Hulse–Taylor binary pulsar, 83, 188,
 189, 302–305, 323–326
 Impedance, 440, 525
 Impedance match ratio, 447
 Inertia tensor, of rigid body, 200
 Innermost Stable Circular Orbit
 (ISCO), 174
 Interferometers, 470–536
 advanced, 532–535
 dark fringe, 504–509
 delay line, 480
 detector tensor, 494
 displacement noise, 524–530
 Fabry–Perot, 480–488
 Gaussian beams, 497–503
 locking, 511–515
 Michelson, 470–479
 noise, 515–530
 optical read-out noise, 522
 pattern functions, 496
 thermal noise, 525–528
 Irreducible representations of
 $SO(N)$, 163
 Kepler equation, 177
 Keplerian orbits, 176
 anomalous eccentricity, 315
 Fourier decomposition, 181–183,
 233
 Post-Newtonian corrections,
 317–320
 Lamé coefficients, 459
 aluminum, 459
 Lambda tensor, 9–10
 angular integration, 113
 Landau–Lifshitz energy–momentum
 pseudotensor, 250
 Laplace effect, 275
 Laplacian
 in spherical coordinates, 132
 LCGT, 532, 534
 LIGO, 413, 528–530
 advanced, 532–534
 arms, 480
 finesse, 488
 laser wavelength, 497
 mirror losses, 487
 pole frequency, 493
 waist, 502
 Likelihood, 352–356
 Likelihood function, 347
 Linear momentum losses, 40, 130,
 139
 Linearization
 Christoffel symbol, 17, 48
 Riemann tensor, 5, 48
 Linearized theory
 action, 70–81
 energy–momentum
 conservation, 7
 equations of motion, 6
 symmetries, 4
 LISA, 534–535
 LISA Pathfinder, 534
 Local inertial frames, 15
 Lock acquisition, 515
 Locking, 511–515
 Lorentz gauge, 6
 Lorentz transformations, 5
 Loss angle, 526
 Luminosity, 113
 Luminosity distance, 192
 Mass momenta
 definition, 107
 Matched asymptotic expansion, 249

bounds on the mass, 82
 helicity, 98–99
 massive, 81–95
 non-linear couplings, 74–79
 propagator, 74
 spin, 66–70
 GRAVITON project, 469
 Gravity
 as a field theory, 66–95
 linearized, 53–65
 non-renormalizable, 79
 Green’s function, retarded, 102, 257
 GW bursters, 413
 GWIC, 469
 Gyroscopes and freely falling frame, 16
 $h_{3/\text{yr}}$, 375
 Hadamard regularization, 300
 Harmonic coordinates, 242
 Harmonic gauge, 6, 242
 Hereditary terms, in the PN
 expansion, 267–275
 Hermite–Gauss modes, 503
 Hilbert gauge, 6
 Hooke’s law, 459
 Hough transform, 385–386
 Hubble expansion rate, 193, 194, 395
 Hulse–Taylor binary pulsar, 83, 188,
 189, 302–305, 323–326
 Impedance, 440, 525
 Impedance match ratio, 447
 Inertia tensor, of rigid body, 200
 Innermost Stable Circular Orbit
 (ISCO), 174
 Interferometers, 470–536
 advanced, 532–535
 dark fringe, 504–509
 delay line, 480
 detector tensor, 494
 displacement noise, 524–530
 Fabry–Perot, 480–488
 Gaussian beams, 497–503
 locking, 511–515
 Michelson, 470–479
 noise, 515–530
 optical read-out noise, 522
 pattern functions, 496
 thermal noise, 525–528
 Irreducible representations of
 $SO(N)$, 163
 Kepler equation, 177
 Keplerian orbits, 176
 anomalous eccentricity, 315
 Fourier decomposition, 181–183,
 233
 Post-Newtonian corrections,
 317–320
 Lamé coefficients, 459
 aluminum, 459
 Lambda tensor, 9–10
 angular integration, 113
 Landau–Lifshitz energy–momentum
 pseudotensor, 250
 Laplace effect, 275
 Laplacian
 in spherical coordinates, 132
 LCGT, 532, 534
 LIGO, 413, 528–530
 advanced, 532–534
 arms, 480
 finesse, 488
 laser wavelength, 497
 mirror losses, 487
 pole frequency, 493
 waist, 502
 Likelihood, 352–356
 Likelihood function, 347
 Linear momentum losses, 40, 130,
 139
 Linearization
 Christoffel symbol, 17, 48
 Riemann tensor, 5, 48
 Linearized theory
 action, 70–81
 energy–momentum
 conservation, 7
 equations of motion, 6
 symmetries, 4
 LISA, 534–535
 LISA Pathfinder, 534
 Local inertial frames, 15
 Lock acquisition, 515
 Locking, 511–515
 Lorentz gauge, 6
 Lorentz transformations, 5
 Loss angle, 526
 Luminosity, 113
 Luminosity distance, 192
 Mass momenta
 definition, 107
 Matched asymptotic expansion, 249

- Matched filtering, 343–413
 bursts, 361–365
 coalescences, 387–392
 parameters estimation, 350–356
 periodic signals, 371–386
 stochastic backgrounds, 392–413
 Maximum likelihood estimation, 352–356
 Memory effect
 linear, 300
 non-linear, 274
 Mesa beams, 503
 Michelson interferometer, 470–479
 Microlensing, 45
 MiniGRAIL, 434, 468
 strain sensitivity, 468
 Mode cleaner
 input, 503
 output, 510
 Modulation index, 377, 505
 Momentum flux, 39
 Momentum radiated by GWs, 130
 Monopole radiation
 absent for GWs, 112
 Multi-index notation, 134
 Multipolar post-Minkowskian
 (MPM) expansion, 256
 Multipole moments, 139–155
 algorithmic, 256
 current quadrupole, 125–131
 mass octupole, 125–131
 mass quadrupole, 109–124
 radiative, 266
 NAUTILUS, 445, 453, 469
 strain sensitivity, 454
 Near zone, 238
 Newtonian limit, 240–241
 Newtonian noise, 525
 Neyman construction, 348
 Neyman-Pearson criterium, 354
 NIOBE, 469
 Noether's theorem, 53–58
 Noise
 $1/f$, 339, 507
 amplifier, 443–444
 non-stationary, 406
 thermal, 437–442
 white, 339
 Non-central chi-squared density, 361
 Null instrument, 504
 Nyquist force, 438
 Ω_{gw} , 395
 Octupole radiation, 125–131,
 161–162
 Overlap reduction function, 402
 Paraxial propagator, 498–503
 Pattern functions, 339–342
 bars, 342, 425–426
 interferometers, 342, 494–496
 sphere, 342
 Pauli–Fierz action, 70–81
 Pauli–Fierz mass term, 87
 Penzias, A., 392
 Periodic signals
 bar's sensitivity, 454–455
 interferometer's sensitivity, 530
 matched filtering, 371–386
 Photon
 absence of dipole radiation, 112
 angular momentum states,
 98–99
 massive, 84–86
 Piezoelectric transducers, 428
 Planck mass, 80
 Pockels cell, 505
 Poincaré group, representations,
 70–71, 96–97
 Poincaré transformations, 5
 Poisson distribution, 371, 516
 Poisson integral, 247
 Poisson ratio, 459
 of Al5056, 459
 Polarization tensors, 12
 Post-Minkowskian expansion,
 253–259
 Post-Newtonian expansion, 237–249
 1PN, 242–245
 for coalescing binaries, 289–299
 hereditary terms, 267–275
 limit of validity, 247–249,
 265–266
 multipolar, 260
 tail integral, 267–275
 Posterior probability, 347
 Pound–Drever–Hall locking, 509,
 513–515
 Power recycling, 510
 Power spectrum, single-sided, 338
 Precession of rigid bodies, 204–205
 Prior probability, 347
 Proca Lagrangian, 84
 Proper detector frame, 19–26
 Proper distance, 13
 Proper time, 13
 PSR B1534+12, 83, 329–331
 PSR B1913+16, *see* Hulse–Taylor
 binary pulsar
 PSR J0737–3039 (double pulsar),
 326–329
 Pulsars
 braking index, 204, 380
 coherent searches, 382
 dispersion in the interstellar
 medium, 311–312
 glitches, 313, 380
 hierarchical searches, 384
 incoherent searches, 383
 magnetosphere, 305
 spindown age, 380
 Pure-spin $s = 2$ tensor spherical
 harmonics, 148
 Pure-spin vector harmonics, 147
 Pustovoit, V. I., 470
 Quadrupole formula controversy,
 277, 299
 Quadrupole moment, 109, 113
 shift of the origin, 122
 spherical components, 141
 Quadrupole radiation, 109–121
 radiated angular momentum,
 114–116
 radiated power, 113, 142
 Quality factor, 419
 Quantum limit, 448
 bars, 446–452
 interferometers, 522–524
 Quantum non-demolition, 449–452
 Radiation pressure, 519–522
 Radiation reaction, 275–279
 Radiative coordinates, 266
 Rayleigh distribution, 360
 Rayleigh range, 501
 Reciprocity relations, 481
 Recoil, due to GW backreaction, 279
 Redshift of gravitons, 45
 in FRW cosmology, 191
 Reflection coefficient, 480
 Relaxed Einstein equations, 250–252
 Renormalization group
 and definition of GWs, 34
 Resonant bars
 absorption cross-section,
 421–423
 bandwidth, 444
 detector tensor, 425
 effective temperature, 444–445
 higher modes, 423
 mode expansion, 417
 noise spectral density, 436–437,
 440, 441, 443, 445
 pattern functions, 425
 quantum limit, 446–452,
 457–458
 response to bursts, 415–419
 response to periodic GWs,
 420–423
 transfer function, 419, 431
 Resonant sideband extraction, 533
 Resonant spheres, 459–468
 cross-section, 465
 normal modes, 461–463
 Resonant transducers, 427–435
 Restricted PN approximation, 297
 Riemann normal coordinates, 16
 Riemann tensor, xvii
 linearized, 5
 Rigid bodies, kinematics, 200–201
 Rigid ruler, 19
 Roemer time delay, 306–307
 ROG collaboration, 453
 Root-sum-square (rss) amplitude,
 364
 Sagnac effect, 20
 Schnupp asymmetry, 506, 507
 Schnupp locking, 515
 Seismic noise, 524
 Shapiro time delay, 308–310
 range and shape, 321
 Shifting algorithm, 371
 Shklovsky effect, 322
 Short-wave expansion, 26–47
 Shot noise, 516–519
 Sidebands, 476, 505
 Sight distance to coalescing binaries,
 391, 529, 533
 Signal recycling, 532–533
 Signal-to-noise ratio
 bursts, 361–365
 coalescences, 390
 definition, 344
 optimal, 345
 periodic signals, 371–386
 Sine-Gaussian waveform, 363
 Singular perturbation theory, 248

- Spectral density
 bars, 436–437, 440, 441, 443, 445
 single-sided, 338
- Speed of GWs, 7, 273
- Speed of sound
 aluminum, 416
 CuAl, 468
- Spherical components of tensors, 140–144
- Spherical harmonics
 l generic, 142
 $l = 2$, 140
 addition theorem, 133
- Spheroidal modes, 461, 463
- Spin-2 tensor harmonics, 148–151
- Spindown parameters, 313
- Spinor spherical harmonics, 145
- SQUID, 434
- Standard candles, 194
- Standard quantum limit, 448, 522–524
- STF projection, 134
- STF tensors, 133
- Stochastic backgrounds, 392–413
 chopping, 411
 multiple-detector correlation, 409
 single detectors, 397–400
 two-detector correlation, 400–409
- Strain amplitude, 337
- Strain sensitivity, 338
- Tail integral, 274
- TAMA300, 480, 528–530
- Templates, 351
 for coalescing binaries, 387
 orthogonal, 389
- Tensor spherical harmonics, 144–151
- TFCLUSTERS algorithm, 369, 413
- Thermal compensation, 532
- Thermal noise
 bars, 437–442
 interferometers, 525–528
- Thermo-elastic noise, 527
- Tidal radius, 220
- Time-frequency analysis, 365

- Transducers
 active, 432
 capacitive, 432
 for resonant bars, 427–435
 magnetic, 432
 parametric, 432
 piezoelectric, 428
- Transfer function, 336
 bar, 419
 bar-transducer, 431
 interferometer with
 Fabry–Perot cavities, 493
- Transmission coefficient, 480
- True anomaly, 178
- TT frame, 17–19
- TT gauge, 7–12
 projection onto, 9
- Units $\hbar = c = 1$, 66
- Vainshtein radius, 92–95
- van Dam-Veltman-Zakharov (vDVZ)
 discontinuity, 90
- Vector spherical harmonics, 145–148
- VIRGO, 528–530
 advanced, 532–534
 arms, 480
 finesse, 488
 laser wavelength, 497
 mirror losses, 487
 optical layout, 510
 pole frequency, 493
 waist, 502
- WaveBurst algorithm, 413
- Wavelets, 368
- Weber, J., 415, 470
- Wiener filter, 345
- Wiener–Khinchin relation, 339
- Wilson, R., 392
- Wobble radiation, 205–211
- \mathcal{Y}_{ij}^{2m} , basis for $l = 2$ traceless symmetric tensors, 140, 143
- Young diagrams, 163
- Young modulus, 416, 459
- Yukawa potential, 68