

References

- [1] C. W. Misner, K. S. Thorne, and J. A. Wheeler, *Gravitation*, W. H. Freeman and Company (1973).
- [2] B. F. Schutz, *A first course in general relativity*, Cambridge University Press (1985).
- [3] K. S. Thorne, *Gravitational radiation*, in: *Three hundred years of gravitation* p. 330-458, eds: S. Hawking and W. Israel, Cambridge University Press (1987).
- [4] R. A. Hulse and J. H. Taylor, *Astrophys. J.* 195 (1975) L51.
- [5] J. H. Taylor and J. M. Weisberg, *Astrophys. J.* 345 (1989) 434.
- [6] J. H. Taylor, *Testing relativistic gravity with binary and millisecond pulsars* in: *General relativity and gravitation* p. 287-294, eds: R. J. Gleiser, C. N. Kozameh, and O. M. Moreschi, Institute of Physics (1993).
- [7] J. Weber, *Physical Review* 117 (1960) 306.
- [8] J. Weber, *Physical Review Letters* 22 (1969) 1320.
- [9] R. Weiss, *Electromagnetically coupled broadband gravitational antenna*, Quarterly Progress Report of the Research Laboratory of Electronics of the Massachusetts Institute of Technology 105 (1972) 54.
- [10] G. E. Moss, L. R. Miller, and R. L. Forward, *Applied Optics* 10 (1971) 2495.
- [11] A. Abramovici, W. E. Althouse, R. W. P. Drever, Y. Gürsel, S. Kawamura, F. J. Raab, D. Shoemaker, L. Sievers, R. E. Spero, K. S. Thorne, R. E. Vogt, R. Weiss, S. E. Whitcomb and M. E. Zucker, *Science* 256 (1992) 325.
- [12] The VIRGO collaboration, *VIRGO Final Design Report* (1997).
- [13] K. Danzmann, H. Lück, A. Rüdiger, R. Schilling, M. Schrempel, W. Winckler, J. Hough, G. P. Newton, N. A. Robertson, H. Ward, A. M. Campbell, J. E. Logan, D. I. Robertson, K. A. Strain, J. R. J. Bennett, V. Kose, M. Kühne, B. F. Schutz, D. Nicholson, J. Shuttleworth, H. Welling, P. Aufmuth, R. Rinkleff, A. Tünnermann and B. Willke, *Proposal for a 600m Laser-Interferometric Gravitational Wave Antenna*, Max-Planck-Institut für Quantenoptik Report 190, Garching (Germany) (1994).
- [14] K. Tsubono, 300-m Laser Interferometer Gravitational Wave Detector (TAMA300) in Japan, in: *Gravitational Wave Experiments* p. 112-114, eds: E. Coccia, G. Pizzella, and F. Ronga, World Scientific (1995) .
- [15] R. W. P. Drever, Fabry-Perot cavity gravity-wave detectors, in: *The detection of gravitational waves* p. 306-328, ed: D. G. Blair, Cambridge University Press (1991) .
- [16] C. N. Man, D. Shoemaker, M. Pham Tu and D. Dewey, *Physics Letters A* 148 (1990) 8.
- [17] K. A. Strain and B. J. Meers, *Physical Review Letters* 66 (1991) 1391.
- [18] P. Fritschel, D. Shoemaker and R. Weiss, *Applied Optics* 31 (1992) 1412.
- [19] M. W. Regehr, *Signal Extraction and Control for an Interferometric Gravitational Wave Detector*, Ph. D thesis, California Institute of Technology (1995).
- [20] M. W. Regehr, F. J. Raab and S. E. Whitcomb, *Optics Letters* 20 (1995) 1507.
- [21] J. A. Giaime, *Studies of Laser Interferometer Design and a Vibration Isolation System for Interferometric Gravitational Wave Detectors*, Ph. D thesis, Massachusetts Institute of Technology (1995).
- [22] D. Sigg, N. Mavalvala, J. Giaime, P. Fritschel, and D. Shoemaker, *Applied Optics* 37 (1998) 5687.

- [23] D. Babusci, H Fang, G. Giordano, G. Matone, L. Matone and V. Sannibale, Physics Letters A 226 (1997) 31.
- [24] D. Schnier, J. Mizuno, G. Heinzel, H. Lück, A. Rüdiger, R. Schilling and M. Schrempel, W. Winkler and K. Danzmann, Physics Letters A 225 (1997) 210.
- [25] P. Fritschel, G. González, B. Lantz, P. Saha, and M. Zucker, Physical Review Letters 80 (1998) 3181.
- [26] S. Moriwaki and the TAMA collaboration, in: *Gravitational Wave Detection* p. 281-286, eds. K. Tsubono, M.-K. Fujimoto and K. Kuroda, Universal Academy Press (1997).
- [27] F. J. Raab, private communication (1997).
- [28] S. Sato, Ph. D thesis, The Graduate University for Advanced Studies (1998).
- [29] G. Heinzel, K. A. Strain, J. Mizuno, K. D. Skeldon, B. Willke, W. Winkler, R. Schilling, A. Rüdiger, and K. Danzmann, Physical Review Letters 81 (1998) 5493.
- [30] K. Kawabe, S. Nagataki, M. Ando, K. Tochikubo, N. Mio and K. Tsubono, Applied Physics B 62 (1996) 135.
- [31] K. Kawabe, *Development of a 3-m Fabry-Perot-Michelson interferometer*, Ph.D thesis, University of Tokyo (1998).
- [32] M. Ando, K. Arai, K. Kawabe, K. Tsubono, Physics Letters A 248 (1998) 145.
- [33] M. Ando, K. Kawabe and K. Tsubono, Physics Letters A 237 (1997) 13.
- [34] T. Nakamura, in: *Detection of gravitational waves* (in Japanese) p. 1-166, eds: T. Nakamura, N. Mio, M. Ohashi, Kyoto University Academy Press (1998).
- [35] Kip S. Thorne, in: *Proceedings of the Snowmass 95 Summer Study on Particle and Nuclear Astrophysics and Cosmology*, eds: E. W. Kolb and R. Peccei, World Scientific (1995).
- [36] P. Bender, A. Brillet, I. Ciufolini, A. M. Cruise, C. Cutler, K. Danzmann, F. Fidecaro, W. M. Folkner, J. Hough, P. McNamara, M. Petersen, D. Robertson, M. Rodrigues, A. Rüdiger, M. Sandford, G. Schäfer, R. Schilling, B. Schutz, C. Speake, R. T. Stebbins, T. Sumner, P. Touboul, J.-Y. Vinet, S. Vitale, H. Ward, W. Winkler, *LISA Pre-Phase A Report Second Edition* (1998).
- [37] P. Astone, M. Bassan, P. Bonifazi, P. Carelli, M. G. Castellano, G. Cavalari, E. Coccia, C. Cosmelli, V. Favone, S. Frasca, E. Majorana, I. Modena, G. V. Pallottino, G. Pizzella, P. Rapagnani, F. Ricci, and M. Visco, Physical Review D 47 (1993) 362.
- [38] E. Mauceli, Z. K. Geng, W. O. Hamilton, W. W. Johnson, S. Merkowitz, A. Morse, B. Price, and N. Solomonson, Physical Review D 54 (1996) 1264.
- [39] D. G. Blair, I. S. Heng, E. N. Ivanov, F. van Kann, N. P. Linthorne, M. E. Tobar, and P. J. Turner, in: *Gravitational Wave Experiments* p. 144-160, eds: E. Coccia, G. Pizzella, and F. Ronga, World Scientific (1995).
- [40] P. Astone, M. Bassan, P. Bonifazi, F. Bronzini, M. G. Castellano, E. Coccia, C. Cosmelli, V. Favone, S. Frasca, E. Majorana, I. Modena, G. V. Pallottino, G. Pizzella, P. Rapagnani, F. Ricci, and M. Visco, Europhysics Letters 16 (1991) 231.
- [41] M. Cerdonio, L. Franceschini, G. Fontana, R. Mezzena, S. Paoli, G. A. Prodi, S. Vitale, J. P. Zendri, M. Biasotto, M. Lollo, F. Bronzini, R. Macchietto, G. Maron, A. Ortolan, M. Strollo, G. Vedovato, M. Bonaldi, P. Falferi, E. Cavallini, P. L. Fortini, E. Montanari, L. Taffarello, A. Colombo, D. Pascoli, B. Tiveron, in: *Gravitational Wave Experiments* p. 176-194, eds: E. Coccia, G. Pizzella, and F. Ronga, World Scientific (1995).
- [42] P. F. Michelson, L. Mann, R. Penny, J. Henderson, D. McKenzie, C. Zhou, in: *Gravitational Wave Experiments* p. 195-200, eds: E. Coccia, G. Pizzella, and F. Ronga, World Scientific (1995).
- [43] T. Suzuki, in: *Gravitational Wave Experiments* p. 115-127, eds: E. Coccia, G. Pizzella, and F. Ronga, World Scientific (1995).

- [44] N. Kondo, *Disk-type resonant antenna with a laser transducer for monitoring gravitational waves*, Ph. D thesis, University of Tokyo (1998).
- [45] W. W. Johnson and S. M. Merkowitz, Physical Review Letters 70 (1993) 2367.
- [46] S. M. Merkowitz and W. W. Johnson, Physical Review D 53 (1996) 5377.
- [47] V. B. Braginsky, and M. E. Gertsenshtein, Soviet Physics — JETP Letters 5 (1967) 287.
- [48] L. B. Iess, G. Giampieri, A. Vecchio, R. Ambrosini, G. Comoretto, Y. Koyama, and A. Messeri, *Search for massive coalescing binaries with the spacecraft ULYSSES*, in: *Gravitational wave experiments* p. 64-69, eds: E. Coccia, G. Pizzella, F. Ronga, World Scientific (1995).
- [49] B. Bertotti, R. Ambrosini, J. W. Armstrong, S. W. Asmar, G. Comoretto, G. Giampieri, L. Iess, Y. Koyama, A. Messeri, A. Vecchio, and H. D. Wahlquist, Astronomy and Astrophysics 296 (1995) 13.
- [50] M. V. Sazhin, Soviet Astronomy 22 (1978) 36.
- [51] S. Detweiler, Astrophysical Journal 234 (1979) 1100.
- [52] M. P. McHugh, G. Zalamansky, and F. Vernotte, Physical Review D 54 (1996) 5993.
- [53] S. Miyoki, *Development of a 100-meter Delay-Line Laser Interferometer*, Ph. D thesis, University of Tokyo (1996).
- [54] C. M. Caves, Physical Review D 23 (1981) 1693.
- [55] N. Mio, in: *Technical investigation of gravitational wave antennas* (in Japanese), eds: N. Mio, M. Ohashi, (1992).
- [56] P. R. Saulson, Physical Review D 42 (1990) 2437.
- [57] A. Gillespie, and F. Raab, Physics Letters A 178 (1993) 357.
- [58] A. Gillespie, and F. Raab, Physics Letters A 190 (1994) 213.
- [59] T. Uchiyama, D. Tatsumi, T. Tomaru, M. E. Tobar, K. Kuroda, T. Suzuki, N. Sato, A. Yamamoto, T. Haruyama, T. Shintomi, Physics Letters A 242 (1998) 211.
- [60] D. Shoemaker, R. Schilling, L. Schnupp, W. Winkler, K. Maischberger, and A. Rüdiger, Physical Review D 38 (1988) 423.
- [61] M. A. Barton and K. Kuroda, Review of Scientific Instruments 65 (1994) 3775.
- [62] M. A. Barton, N. Kanda, and K. Kuroda, Review of Scientific Instruments 67 (1996) 3994.
- [63] A. Rüdiger, R. Schilling, L. Schnupp, W. Winkler, H. Billing, and K. Maischberger, Opt. Acta 28 (1981) 641.
- [64] F. Barone, E. Calloni, L. Di Fiore, A. Grado, P. Hello, L. Milano, G. Russo, Physics Letters A 217 (1996) 90.
- [65] K. D. Skeldon, K. A. Strain, A. I. Grant, and J. Hough, Review of Scientific Instrument 67 (1996) 2443.
- [66] A. Araya, N. Mio, K. Tsuhono, K. Suehiro, S. Telada, M. Ohashi, and M. Fujimoto, Applied Optics 36 (1997) 1446.
- [67] A. Telada, *Development of a Mode Cleaner for a Laser Interferometer Gravitational Wave Detector*, Ph. D thesis, The Graduate University for Advanced Studies (1997).
- [68] N. Mio, in: *Detection of gravitational waves*. (in Japanese) p. 197-229, eds: T. Nakamura, M. Mio, M. Ohashi, Kyoto University Academy Press (1998).
- [69] B. Caron, A. Dominjon, R. Flaminio, F. Marion, L. Massonnet, R. Morand, B. Mours, D. Verkindt and M. Yvert, Nuclear Instruments and Methods in Physics Research A 360 (1995) 375.
- [70] R. Flaminio and H. Heitmann, Physics Letters A 214 (1996) 112.
- [71] K. Arai, private communication (1998).

- [72] A. Araya, *Optical Mode Cleaner for the Interferometric Gravitational wave Detector*. Ph.D thesis, University of Tokyo (1994).
- [73] S. Moriwaki, in: *Technical investigation of gravitational wave antennas* (in Japanese) p. 222-233, eds: N. Mio, M. Ohashi (1992).
- [74] L. Sievers, private communication (1997).
- [75] M. Ando, *Control of a Fabry-Perot-type laser interferometric gravitational wave detector*. (in Japanese), Master thesis, University of Tokyo (1996).
- [76] Discussions in the TAMA group (1998).
- [77] N. Uehara, A. Ueda, K. Ueda, H. Sekiguchi, T. Mitake, K. Nakamura, N. Kajima, and I. Kataoka, *Optics Letters* 20 (1995) 530.
- [78] E. Morrison, B. J. Meers, D. I. Robertson, and H. Ward, *Applied Optics* 33 (1994) 5037.
- [79] N. Mavalvala, *Alignment issues in laser interferometric gravitational wave detectors*, Ph. D thesis, Massachusetts Institute of Technology (1997).

Acknowledgements

It would have been impossible, beyond all question, to complete this doctoral work without the supports of many people.

First of all, I am deeply indebted to my supervisor, Professor Kimio Tsubono, who introduced me to this energetic field of gravitational wave detection. In addition, Prof. Tsubono encouraged me to start the power recycling experiments on the 3-m prototype interferometer. I am also indebted to Dr. Keita Kawabe for his scientific insights and technical supports. I have learned a lot of things from him on the fundamentals and art of the physical experiments. I am grateful to the members of Tsubono laboratory for their support. In particular, Mr. Koji Ara, with patient support and discussions, was instrumental in the completion of this work.

I would like to thank the members of the TAMA project for their useful discussions. In addition, some of the instruments used in this work were provided by the TAMA project and its members. I am especially grateful to Professor Norikatsu Mio, Dr. Shigenori Moriwaki, and Dr. Masatake Ohashi for support of experimental instruments and for their useful and suggestive comment on the signal-separation scheme.

Finally, I am grateful to my parents for every thing.

This research is supported by Research Fellowships of the Japan Society for the Promotion of Science for Young Scientists, and by a Grant-in-Aid for Creative Basic Research of the Ministry of Education.

play in disease prevention. However, the relationship between the different types of exercise and the incidence of disease is not clear.

It is believed by [unclear] that exercise may reduce the risk of developing certain diseases and conditions by improving the immune system and reducing the risk of developing certain diseases. For example, it has been shown that regular exercise can help to prevent heart disease, stroke, diabetes, and some types of cancer. It is also believed that exercise can help to improve mental health, reduce stress, and increase overall well-being.

Exercise is a form of physical activity that involves movement and coordination of the body's muscles and bones. It can be done in various ways, such as walking, running, swimming, cycling, or playing sports. Exercise can be done at any time of day, but it is recommended to do it regularly, such as 30 minutes a day, five days a week. It is important to choose activities that you enjoy and that fit your lifestyle. For example, if you enjoy swimming, it is better to swim than to run, even if you like running. It is also important to stay hydrated and to eat a healthy diet while exercising.

Exercise is important for maintaining a healthy weight, preventing diseases, and improving overall health. It can also help to reduce stress, improve mood, and increase energy levels. Exercise can be done alone or with others, and it can be done in various ways, such as walking, running, swimming, or cycling. It is important to choose activities that you enjoy and that fit your lifestyle. For example, if you enjoy swimming, it is better to swim than to run, even if you like running. It is also important to stay hydrated and to eat a healthy diet while exercising.

Exercise is important for maintaining a healthy weight, preventing diseases, and improving overall health. It can also help to reduce stress, improve mood, and increase energy levels. Exercise can be done alone or with others, and it can be done in various ways, such as walking, running, swimming, or cycling. It is important to choose activities that you enjoy and that fit your lifestyle. For example, if you enjoy swimming, it is better to swim than to run, even if you like running. It is also important to stay hydrated and to eat a healthy diet while exercising.

Exercise is important for maintaining a healthy weight, preventing diseases, and improving overall health. It can also help to reduce stress, improve mood, and increase energy levels. Exercise can be done alone or with others, and it can be done in various ways, such as walking, running, swimming, or cycling. It is important to choose activities that you enjoy and that fit your lifestyle. For example, if you enjoy swimming, it is better to swim than to run, even if you like running. It is also important to stay hydrated and to eat a healthy diet while exercising.

