

# The extended Einstein-Maxwell-Aether-Axion model: Exact solutions for axionically controlled pp-wave aether modes

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

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## Abstract

© 2018 World Scientific Publishing Company. The extended Einstein-Maxwell-Aether-Axion model describes internal interactions inside the system, which contains gravitational, electromagnetic fields, the dynamic unit vector field describing the velocity of an aether, and the pseudoscalar field associated with the axionic dark matter. The specific feature of this model is that the axion field controls the dynamics of the aether through the guiding functions incorporated into Jacobson's constitutive tensor. Depending on the state of the axion field, these guiding functions can control and switch on or switch off the influence of acceleration, shear, vorticity and expansion of the aether flow on the state of physical system as a whole. We obtain new exact solutions, which possess the pp-wave symmetry, and indicate them by the term pp-wave aether modes in contrast to the pure pp-waves, which cannot propagate in this field conglomerate. These exact solutions describe a specific dynamic state of the pseudoscalar field, which corresponds to one of the minima of the axion potential and switches off the influence of shear and expansion of the aether flow; the model does not impose restrictions on Jacobson's coupling constants and on the axion mass. Properties of these new exact solutions are discussed.

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## Keywords

Alternative theories of gravity, axion, dynamic aether, unit vector field

## References

- [1] LIGO Scientific Collab. and Virgo Collab., Fermi Gamma-ray Burst Monitor, and INTEGRAL, Gravitational waves and gamma-rays from a binary neutron star merger: GW170817 and GRB 170817
- [2] A, *Astrophys. J. Lett.* 848, L13 (2017).
- [3] H. Stephani, D. Kramer, M. MacCallum, C. Hoenselaers and E. Herlt, *Exact Solutions of Einstein's Field Equations* (University Press, 2003).
- [4] C. W. Misner, K. S. Thorne and J. A. Wheeler, *Gravitation* (Freeman, 1973).
- [5] V. D. Zakharov, *Gravitational Waves in Einstein's Theory* (Halsted Press, 1973).
- [6] T. Yu. Alpin and A. B. Balakin, *Eur. Phys. J. C* 77, 699 (2017).
- [7] T. Jacobson and D. Mattingly, *Phys. Rev. D* 64, 024028 (2001).
- [8] T. Jacobson and D. Mattingly, *Phys. Rev. D* 70, 024003 (2004).
- [9] C. Heinicke, P. Baekler and F. W. Hehl, *Phys. Rev. D* 72, 025012 (2005).

- [10] T. Jacobson, Einstein aether gravity: A status report, PoSQG-Ph 020, 020 (2007).
- [11] A. B. Balakin, Phys. Rev. D 94, 024021 (2016).
- [12] A. B. Balakin and J. P. S. Lemos, Ann. Phys. 350, 454 (2014).
- [13] R. D. Peccei and H. R. Quinn, Phys. Rev. Lett. 38, 1440 (1977).
- [14] S. Weinberg, Phys. Rev. Lett. 40, 223 (1978).
- [15] F. Wilczek, Phys. Rev. Lett. 40, 279 (1978).
- [16] W.-T. Ni, Phys. Rev. Lett. 38, 301 (1977).
- [17] P. Sikivie, Phys. Rev. Lett. 51, 1415 (1983).
- [18] F. Wilczek, Phys. Rev. Lett. 58, 1799 (1987).
- [19] F. W. Hehl and Yu. N. Obukhov, Foundations of Classical Electrodynamics: Charge, Flux, and Metric (Birkhauser, 2003).
- [20] A. B. Balakin and W.-T. Ni, Class. Quantum Grav. 31, 105002 (2014).
- [21] T. Yu. Alpin and A. B. Balakin, Int. J. Mod. Phys. D 25, 1650048 (2016).
- [22] A. B. Balakin, Symmetry (MDPI) 8, 56 (2016).