Bab 5

Penutup

4.1. Kesimpulan

Berdasarkan hasil penelitian dan pembahasan yang telah dilakukan, maka dapat dikatakan terdapat perbedaan teoritis dalam kajian neutrino Dirac dan neutrino Majorana ketika dikaitkan dengan gravitas Einstein, hal ini bisa dilihat ketika ditinjau dari perubahan osilasi dan energi gangguan gravitasi, Dengan energi gangguan gravitasi untuk neutrino Dirac

$$E_{\tilde{m}}^{(\pm)} \approx \frac{4}{5}\frac{M\Omega R^2}{r^3}L^{\hat{z}} + (\hbar k_0)\left[\left(1-\frac{2M}{r}\right)+\frac{1}{2}\tilde{m}^2\right] + (\hbar k_0)\frac{M}{r}\left[\left(G_{0(\pm)}^{\text{Dirac}}\right)+\left(G_{1(\pm)}^{\text{Dirac}}\right)\tilde{m}+\left(G_{2(\pm)}^{\text{Dirac}}\right)\tilde{m}^2\right]$$
$$+(\hbar k_0)\frac{M\Omega R^2}{r^2}\left[\left(K_0^{\text{Dirac}}\right)+\left(K_1^{\text{Dirac}}\right)\tilde{m}+\left(K_2^{\text{Dirac}}\right)\tilde{m}^2\right]$$

sementara itu energi gangguan gravitasi terhadap neutrino Majorana

$$E_{\tilde{m}}^{(\pm)} \approx \frac{4}{5}\frac{M\Omega R^2}{r^3}L^{\hat{z}} + (\hbar k_0)\left[\left(1-\frac{2M}{r}\right)+\frac{1}{2}\tilde{m}^2\right] + (\hbar k_0)\frac{M}{r}\left[\left(G_{0(\pm)}^{\text{Maj}}\right)+\left(G_{1(\pm)}^{\text{Maj}}\right)\tilde{m}+\left(G_{2(\pm)}^{\text{Maj}}\right)\tilde{m}^2\right]$$
$$+(\hbar k_0)\frac{M\Omega R^2}{r^2}\left[\left(K_0^{\text{Maj}}\right)+\left(K_1^{\text{Maj}}\right)\tilde{m}+\left(K_2^{\text{Maj}}\right)\tilde{m}^2\right]$$

Dari dua persamaan energi gangguan gravitasi terhadap osilasi neutrino di atas dengan jelas terlihat adanya perbedaan kesamaan pola akan tetapi fase gravitasi yang bekerja dalam masing-masing osilasi disusun oleh struktur yang berbeda.

4.2. Saran

Berdasarkan kesimpulan di atas, maka peneliti menyarankan beberapa hal diantaranya sebagai berikut:

1. Hasil penelitian ini hendaknya dapat dijadikan pembelajaran dan informasi bagi para pengembang fisika untuk meningkatkan pengetahuan khususnya dalam kajian teori ilmu Fisika.
2. Untuk penelitian selanjutnya diharapkan dapat mengembangkan penelitian ini dengan lebih fokus dalam komputasi energi gangguan gravitasi dan dinamika osilasi paket gelombang neutrino Dirac dan Majorana.

DAFTAR PUSTAKA

Ali H. Chamseddine, *et. All.* 2010. *Gravity and the Standard Model with Neutrino Mixing*.

Amagh Nduka. 2012. *The Neutrino Mass*. Federal University of Technology, Nigeria. http://www.scirp.org

Bernd Thaller. 1991. *The Dirac Equation*. Springer-Verlag

Bransden B.H. dan Joachain B.H. 2000. *Quantum Mechanics*. Second Edition. Prentice Hall

Carlo Giunti dan Chung W. Kim. 2007. *Fundamentals of Neutrino Physics and Astrophysics*. Oxford University Press.

Carlo Giunti. 2003. *Coherence and Wave Packets in Neutrino Oscillations*. arXiv:hep-ph/0302026v3

Carlo M. Becchi dan Giovanni Ridolfi. 2006. *An Introduction to Relativistic Processes and the Standard Model of Electroweak Interactions*. Springer- Verlag

Caroline. 2004. *Efek Faktor Bentuk Elektromagnetik Neutrino pada Interaksi Neutrino dengan Materi Mampat*. Tesis Universitas Indonesia

Claude Itzykson dan Jean B. Zuber. 1980. *Quantum Field Theory*. Mc Graw- Hill

Czakon M, *et al*. 1999. *Are Neutrinos Dirac or Majorana Particles*?. arXiv:hep-ph/9910357v3

Dinesh Singh, *et al*. 2008. *Can Gravity Distinguish between Dirac and Majorana Neutrinos.* arXiv:gr-qc/0605153v3.

Dinesh Singh, *et al*. 2013. *The Distinction Between Dirac and Majorana Neutrino Wave Packets Due to Gravity and Its Impact on Neutrino Oscillations*. arXiv:gr-qc/0606134v1

Dolgov. 2002. *Neutrinos in Cosmology*. arXiv:hep-ph/0202122 v2.

Eckart Marsch. 2011. *The Two-Component Majorana Equation-Novel Derivations and Known Symmetries.* Journal of Modern Physics, Scientific Resears.

Efrosinin. 2012. *Neutrino Riddles.* Journal of Modern Physics, Scientific resears.

Jentschura dan Wundt. 2013. *From Generalized Dirac Equations to a Candidate for Dark Energi.* University of Science and Technology, USA.

Jites R. Bhat dan Utpal Sarkar. 2009. *Majorana Neutrino Superfluidity and Stability of Neutrino Dark Energi.* arXiv:0805.2482v2.

Masataka Fukugita dan Tsutomu Yanagida. 2003. *Physics of Neutrinos and Application to Astrophysics.* Springer-Verlag

Menon A dan Arun M. Thalapilill. 2008. *Interaction of Dirac and Majorana Neutrinos with Weak Gravitational Field*. arXiv: 0804.3833v2.

Michael Forger dan Hartmann Roemer. 2003. *Currents and the Energi- Momentum Tensor in Classical Field Theory: A Fresh Look at an Old Problem*. Universitas Freiburg, Germany

Michele Maggiore. 2005. *A Modern Introduction to Quantum Field Theory*. Oxford University Press

Murod Abdukhakimov. 2011. *How Dirac and Majorana Equations are Related*.

Nick E. Mavromatos dan Apostolos Pilaftsis. 2012. *Anomalous Majorana Neutrino Masses from Torsionful Quantum Gravity.* arXiv:1209.6387v2.

Palash B. Pal. 2010. *Dirac, Majorana and Weyl fermions.* arXiv:1006.1718v2.

Rasulkhozha dan Sharafiddinov. 2010. O*n the Compound Structures of the Neutrino Mass and Charge.* arXiv:Physics/0305008v2.

Sabin Stoica. 2013. *Neutrino Properties Probed by Lepton Number Violating Processes.* Scientific Research.

Salvotare Capozziello dan Valerio Faraoni. 2010. *Beyong Einstein Gravity, a Survey of Gravitational Theories for Cosmology and Astrophysics*. Universitas Di Napoli Federico.

Salvatore Capozziello, *et al*. 2013. *Weak Forces and Neutrino Oscillations under the standards of Hybrid Gravity with Torsion*. arXiv:1309.3856v3.

Salvatore Esposito dan Nicola Tancredi. 1998. *Flavour Transitions of Dirac- Majorana Neutrinos*. arXiv:hep-ph/9803471v1

Samoil Bilenky. 2010. *Introduction to the Physics of Massive and Mixed Neutrinos.* Springer Heidelberg . New York.

Samoil Bilenky, *et al*. 2003. *Absolute Values of Neutrino Masses*: *Status and Prospects*. arXiv:hep-ph/0211462 v3

Suzuki dan Totsuka. 1998. *Neutrino Physics and Astrophysics*. Proceedings of the XVIII International Conference on Neutrino Physics and Astrophysics, Japan .

Tsao Chang. 2013. *Neutrinos as Superluminal Particles*. Journal of Modern Physics, Scientific Research.

Zee. 2013. *Einstein Gravity in Nutshell*. Princeton University Press

Zhi Zhong Xing dan Shun Zhou. 2010. *Neutrinos in Particle Physics*, *Astronomy and Cosmology*. Zhejiang University Press.