Bell's instability in the laboratory: preparatory investigation

C.-S. Jao[1], S. Vafin[1,2], Y. Chen[1], M. Gross[1], M. Krasilnikov[1], G. Loisch[1], T. Mehrling[3], Jacek Niemiec[4], A. Oppelt[1], A. Martinez de la Ossa[5], J. Osterhoff[3], M. Pohl[1,2], F. Stephan[1]

[1]DESY, Zeuthen, Germany
[2]Institute of Physics and Astronomy, University of Potsdam, Potsdam-Golm, Germany
[3]DESY, Hamburg, Germany
[4]Institute of Nuclear Physics PAN, Krakow, Poland
[5]Institute of Experimental Physics, University Hamburg, Germany

The diffusive shock acceleration at the forward shocks of shell-type supernova remnants is considered as a prime mechanism for the PeV-scale high energy cosmic ray particles. For efficient acceleration, the amplification of interstellar magnetic field are indispensable in the upstream region of the shock. Bell's instability [1], a non-resonant streaming instability driven by cosmic-ray current, is proposed as a candidate for providing the required magnetic turbulence. Recent magnetohydrodynamics (MHD) studies and Particle-In-Cell (PIC) simulations show that the magnetic field fluctuations stronger than the background interstellar field is expectable theoretically [1,2]. In order to demonstrate the saturation level and mechanism of Bell's instability in the laboratory environment, here we attempt to develop a laboratory experiment at Photo Injector Test Facility at DESY, Zeuthen site (PITZ) [3]. In this study, we will first introduce our facility and setup for the experiment. The linear theoretical analysis and nonlinear numerical simulation [4] will be also present to discuss the physical condition that permit Bell's instability to occur in the laboratory.

[1] A. R. Bell, Mon. Not. R. Astron. Soc. 353, 550 (2004).
[2] J. Niemiec et al., Astrophys. J. 709, 1148 (2010).
[3] Y. Chen. et al., arXiv:1803.05540 (2018); NIM A (under review).
[4] R. A. Fonseca et al., PPCF 50, 124034 (2008); PPCF 55, 124011 (2013); Lect. Notes Comp. Sci. 2331, 342 (2002).