Towards a high efficiency amplifier based on Raman amplification

G. Vieux[1], E. Brunetti[1], S. Cipiccia[2], B. Eliasson[1], B. Ersfeld[1], J.P. Farmer[3], M.S. Hur[4], N. Lemos[5], G.H. Welsh[1], S.M. Wiggins[1], X. Yang[6], S.R. Yoffe[1], J.M. Dias[7], D.A. Jaroszynski[1]

[1] *Department of Physics, SUPA and University of Strathclyde, Glasgow, G4 0NG, UK*

[2] *Diamond Light Source, Harwell Science and Innovation Campus, Didcot, OX11 0DE, UK*

[3] *Theoretische Physik I, Heinrich Heine Universität, 40225, Düsseldorf, Germany*

[4] *UNIST, Ulsan, 689-798, South Korea*

[5] *Lawrence Livermore National Laboratory, Livermore, CA, 94550, USA*

[6] *Department of Physics, Capital Normal University, Beijing, 100048, China*

[7] *Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal*

High power, short pulse lasers have become valuable tools for scientists exploring a wide range of phenomena and developing new technologies such as ultra-compact wakefield accelerators [1] and compact light sources [2] with applications ranging from particle physics to biology. To produce ultra-intense, short pulses, large-scale laser facilities rely on the chirped pulse amplification technique and require metre-scale optical components to restrict the laser intensity to below their damage thresholds. They are therefore currently extremely expensive and difficult to maintain. Twenty years ago a novel approach was suggested using plasma as a gain medium to superradiantly amplify a short seed pulse colliding with a counterpropagating pump [3]. This approach is based on the paradigm of three-wave interaction between the two electromagnetic waves and a plasma wave [4]. Since this seminal work, extensive theoretical and experimental studies have been conducted to develop plasma-based amplifiers where the energy exchange between the pump and seed is realised through Raman or Brillouin instability [4]. In this paper, we present an overview of the work that has been carried out by the Strathclyde University group on Raman amplification of short laser pulses [5]. We review the current challenges of increasing the energy transfer efficiency, which is currently low. In particular, we will discuss the use of the pump frequency chirp to control the amplification process.

References

[1] T. Tajima, J. Dawson, Phys. Rev. Lett. **43**, 267 (1979)

[2] D.A. Jaroszynski, G. Vieux, AIP Conf. Proc. **647**, 902 (2002)

[3] G. Shvets et al., Phys. Rev. Lett. **81**, 4879 (1998)

[4] W.L. Kruer, The Physics of Laser Plasma Interactions (Addison-Wesley, Reading, MA, 1988)

[5] G. Vieux et al., New J. Phys. **13**, 063042 (2011); X. Yang et al., Sci. Rep. **5**, 13333 (2015); G. Vieux et al., Sci. Rep. **7**, 2399 (2017)