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GW level microwave pulses in X-band from a combination of a relativistic BWO and a helical-waveguide compressor

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Backward Wave Oscillators (BWO's) utilizing moderately relativistic (~500kV), high-current (~10 kA) electron beams are capable of producing hundreds of MWs of pulsed radiation in the centimeter wavelength range. Such relativistic BWOs (RBWOs) allow for relatively broadband, smooth, frequency-tuning via adjustment of the accelerating potential; making them an attractive source for use in frequency-swept pulse compression.

A collaboration between the University of Strathclyde and the Institute of Applied Physics (IAP) resulted in the development of a 5-fold helically corrugated, frequency-swept, pulse compressor. In the experiment at Strathclyde, the maximum power compression ratio of 25 was achieved by compressing an input microwave pulse of 80 ns duration and 9.65 GHz to 9.05 GHz frequency swept range into a 1.6ns Gaussian-envelope pulse. For an average input power of 5.8 kW generated by a conventional traveling wave tube, a peak pulse output power of 145 kW was measured corresponding to an energy efficiency of 66% [1].

An X-band relativistic BWO, designed to drive a similar compressor, was then built and tested at the IAP, with the accelerating potential provided by a SINUS-6 high-current accelerator. The experimental RBWO operated close to predicted powers (600 –800MW) with its oscillation frequency varied from 10 –9.6GHz via the falling edge of the voltage pulse. It was demonstrated that the ~15ns duration frequency-swept part of the RBWO pulse was effectively compressed resulting in about a 4.5-fold peak power increase with a maximum power of 3.2 GW generated [2]. Future experiments combining a 5-fold helical waveguide with a longer pulse RBWO will be discussed.

[1] L. Zhang, et al, IEEE Trans. Microw. Theory Tech., 63 (3), pp1090-1096, (2015).

[2] V. L. Bratman, et al, Phys. Plasmas 17, 110703 (2010).

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