

# BRILLOUIN AMPLIFICATION--A POWERFUL NEW SCHEME FOR MICROWAVE PHOTONIC COMMUNICATIONS

Steve Yao and Lute Maleki

Jet Propulsion Laboratory, California Institute of Technology

4800 Oak Grove Dr., Pasadena, CA 91109

Tel: 818-393-9031 Fax: 818-393-6773

Email: xsyao@fridge.jpl.nasa.gov

## ABSTRACT

Brillouin amplification in digital photonic systems has been extensively studied by many authors. Unfortunately, it has been proved to be impractical due to its narrow bandwidth and high spontaneous emission noise. Perhaps because of such unsuccessful attempts in the digital domain, the application of Brillouin amplification in analog photonic systems was seldom investigated. In fact, the related Brillouin scattering is generally considered to be harmful and extensive efforts have been devoted to minimize its effect.

We show in this paper both experimentally and analytically that Brillouin amplification can drastically improve the performance and extend the functionality of an analog photonic system if properly used. We obtained a net link gain of 30 dB of an externally modulated photonic link at 5 GHz with an optical power of only 2.61 mW in the photodetector. Such a large and efficient signal amplification will prove extremely important in systems with narrow instantaneous bandwidth but broad overall bandwidth (e.g. widely tunable systems). It can also be used in an opto-electronic oscillator (OEO) to replace the bulky, power consuming, and costly rf amplifiers, resulting better performance with reduced size, power, and cost.

We also demonstrate broadband photonic signal up and down conversion with 14 dB gain by using Brillouin amplification. Such a demonstration makes photonic mixing readily applicable without having to employ high power lasers and high power photodetectors.

We further demonstrate using Brillouin amplification to convert phase modulation into amplitude modulation so that one can use lower loss phase modulators in photonic links to replace conventional Mach-Zehnder modulators. Such a replacement not only results in much higher link gain, but also eliminates the bias drift associated with biasing the Mach-Zehnder modulators. In addition, the Brillouin amplification can also turn a phase modulator into an efficient photonic frequency multiplier with large multiplication factors,

without having to overly drive the modulator nor to use high power lasers. This makes the photonic frequency multiplication practical.

We believe that Brillouin amplification will leap forward the research and development of microwave photonic systems and devices in the time to come.