

# Second harmonic generation in silica whispering-gallery microresonators

May 28, 2017

## 1 Introduction

Literature; origin, set-up, phase-matching, advantages: low pump power, continuous wave, possible applications and impacts

## 2 Experimental set-up and observation of second harmonic signal

Explain the set-up and how to collect the signal; show the typical spectra and corresponding experimental conditions; explain why other nonlinear processes are absent; f1f2 comparison and conditions

In the experiments, a silica microsphere resonator with a diameter of around  $62\mu\text{m}$  is used to enhance the intensity of light and consequently, the second order nonlinear effects. A tapered fiber phase-matched at the telecommunication band couples the pump into the microsphere[1, 2]. This tapered fiber is not able to collect the second harmonic signal efficiently due to phase mismatching at around 780nm and the high radial order of the second harmonic mode[3]. To overcome this problem and collect weak second harmonic signals, another tapered fiber (signal tapered fiber) designed to achieve phase matching condition at second harmonic wavelength is fabricated together with the pump tapered fiber and incorporated into the system as is shown in fig.[set-up]. The tapered fibers can reach critical coupling simultaneously at around 1555nm and 777nm. A fiber coupler split 10% of the pump power from the laser and a polarization controller into a power meter to monitor the input power. The signals collected by the signal tapered fiber are sent into an electron-multiplying CCD (EMCCD) with gratings to extract the spectra. The EMCCD and the pump laser are placed at the same side of the microsphere because of the linear momentum conservation requirement in SHG[3, 4].

### 3 Thermal and Kerr effect assisted phase-matching

Prerequisite phase matching (higher order radial modes) and its problems; P2-P1 relation and how to enhance SH signals; mechanisms for assisted phase-matching; results: dependence on detuning and power; comparison with other SH and silica sphere TH.

### 4 Origin of second order nonlinearity

Theory for surface & bulk 2nd nonlinearity; relationship with polarization  
More eg of SH; sum frequency; (TH?)  
[?]

## References

- [1] J Cheung Knight, G Cheung, F Jacques, and TA Birks. Phase-matched excitation of whispering-gallery-mode resonances by a fiber taper. *Optics letters*, 22(15):1129–1131, 1997.
- [2] Ming Cai, Oskar Painter, and Kerry J Vahala. Observation of critical coupling in a fiber taper to a silica-microsphere whispering-gallery mode system. *Physical review letters*, 85(1):74, 2000.
- [3] Tal Carmon and Kerry J Vahala. Visible continuous emission from a silica microphotonic device by third-harmonic generation. *Nature Physics*, 3(6):430–435, 2007.
- [4] Gregory Kozyreff, JL Dominguez Juarez, and Jordi Martorell. Whispering-gallery-mode phase matching for surface second-order nonlinear optical processes in spherical microresonators. *Physical Review A*, 77(4):043817, 2008.