A 245 Optical Frequency Doubling

A 245.1 Aim of the Experiment

The area of nonlinear optics is of great importance as well for basic research as for industrial applications. In this experiment, the properties of a nonlinear crystal shall be examined as an typical example. For this, the beam of a high-power diode laser at 987 nm (infrared, fundamental wave) is frequency doubled with a potassium niobate crystal to visible light (harmonic wave). The output power of the harmonic wave is measured and optimized by adjusting the polarization and power of the fundamental wave, position of the beam focus inside the crystal and the crystal temperature. The wavelengths of fundamental and harmonic waves are compared with a diffraction grating. A Michelson interferometer is used to compare the wavelengths with interferometric precision. The experiment can be built up from individual components (mirrors, lenses, filters, beam splitters, gratings, photodiodes, etc.). These parts can be placed freely on an optical table ('breadboard').

A 245.2 Required Knowledge

- Generation of harmonics by nonlinearities
- Birefringence
- Phase matching
- Gaussian Beams
- Determination of wavelengths with gratings
- Michelson interferometer
- Coherence and coherence length
- Working principle of diode lasers

A 245.3 Literature

The following (partly in German) can be **obtained from the tutor**, together with a **detailed experiment description**:

- D. Meschede: *Optik, Licht und Laser*, chapters 3.5 and 12, B.G. Teubner Stuttgart-Leipzig 1999,

- Jens Clevorn: *Resonante Frequenzverdopplung mit Diodenlasern zur Spektroskopie bei* $\lambda = 410\ nm$, chapter 3, Diplomarbeit Universität Bonn 1998,

- R. W. Boyd: *Nonlinear Optics*, chapter 2, Academic Press Boston 1992,

- Spectragen, Inc.: *$KNbO_3$ Properties*, http://www.spectragen.com/properties/KNbO3.htm

Further reading: Any textbooks in optics.

A 245.4 Assignments

1. Getting familiar with a diode laser: output power versus injection current, threshold current and quantum efficiency.
2. Calibration of the variable attenuator.
3. Focusing the laser beam into the crystal and optimizing the harmonic power.
4. Measurement of the harmonic power versus the crystal temperature.
5. Measurement of the harmonic power versus the input fundamental power.
6. Measurement of the harmonic power versus the polarization of the fundamental wave.
7. Comparison of fundamental and harmonic wavelengths using a diffraction grating.
8. Setting-up and adjusting a Michelson interferometer; interferometric comparison of the wavelengths of fundamental and harmonic waves.

A 245.5 Procedure and analysis

Further details are described in the full description of the experiment you are supposed to get from the tutor 2 weeks before the experiment.

Best wishes for a successful experiment! Date: January 2005