Introduction to Nonlinear Optics
Project Suggestions, Guidelines and Requirements

1. Below is a list of suggested project topics. These are only suggestions. You are free to work on any project after you have discussed with me and I think that it is reasonable. Most of these projects can be survey, programming or research types unless they are marked. You need to submit a one-page proposal on or before Mar. 3. I prefer each student choosing a different topic. Therefore, you need to talk to me before you decide upon a topic.
2. The project has two parts: 1) report (17% of course grade) and 2) oral presentation (8% of course grade). A progress report should be submitted on Apr. 7. On Apr. 28, the first draft of the final report will be due. I will return your drafts and the final draft will be due on May 14 noon. The oral presentation will be scheduled on May 5.
3. The length of the oral presentation should be about 15-20 min. which includes 3 min for discussion. We will stick to the time limit for presentation.
4. The length of the manuscript including illustrations should be about 10-12 pages long. The style should conform to the style guide in this handout. You should be able to find a MS word template for style on ‘‘scylla.ceas.uwm.edu/766’’.
5. List of references should be collected at the end of the paper. Figures should be properly explained in the text and in the figure captions. Check journals such as Optics Letters and IEEE Photonics Technology Letters to get a feeling on this requirement.
6. The paper and presentation will be graded on the basis of
   (i) Scientific Content - Statement of problem, physical explanation and mathematical analysis.
   (ii) Quality of organization - conform to the format requirements, follow logical order for each section.
   (iii) Use of English - grammar, diction, language.
   (iv) Readability - clarity and appropriate level for audiences.
   (v) Quality of illustrations - captions for table and graphics, are they referred in the text and if the description adequate.
   (vi) References - adequate references, refer to references in text and illustration if these pieces are from the references.
   (vii) Length of report - must follow the length requirements
   (viii) Level of effort - how much work has been done in improving quality of the report.

   Presentations will be graded by instructor as well as your peers.
7. To determine which topic to choose, you can look into the following journals: *IEEE Journal of Quantum Electronics*, *Journal of Optical Society of America A and B*, *Applied Optics*, *Optics Letters*, *Photonics Technology Letters*, *Physical Review Letters* as well as the references at the end of Chapters 18,19 and 21 (Chapters 20 to 23 in 2nd Ed) of the textbook. If you have problems in finding references, I can give you direction and help.
   Note: Our library has all the IEEE journals American Physics Society (APS) journals and Optical Society of America (OSA) online. These invaluable sources of information can be accessed at your home (see ‘‘instructions for download articles at home’’ at scylla.ceas.uwm.edu/766).

Topics for the project

1. Simulation of self-focusing effect
   Self-focusing causes a beam to collapse by itself without a converging lens. This is a programming project. You need to compare numerical results to theory.
2. Simulation of self-bending effect
   Self-bending causes a beam to steer to certain direction without a prism. This is a programming project. You need to compare numerical results to theory.
3. Simulation of self-defocusing
   Self-defocusing causes a beam to expand by itself faster than diffraction without a diverging lens. This is a programming project. You need to compare numerical results to theory.
4. Phase conjugation by nonlinear processes
   Phase conjugation occurs in holograms. The same effect can happen during wave mixing. This makes the self-correction of a beam possible and finds application in adaptive optics.
5. Cascading of second order nonlinear processes
   Efficient third order effects can be achieved by cascading of second order nonlinear processes. Discuss various methods to obtain cascading of second order nonlinear processes.
6. Generation of THz radiation with nonlinear processes
   Nonlinear processes can be used to generate THz radiation that can be used to various areas, such as imaging and communication. The research can discuss novel methods for generation and/or applications of THz sources.
7. Optical bistability based on nonlinear refractive index and/or absorption
   Investigate different ways to make the basic building block of an optical computer.
8. Ultra-short pulses propagation in nonlinear media
   For ultra-short pulses with width of 10 femtosecond or less, very high power can be achieved. Such a high power make the higher order nonlinear effects possible. Further, dispersion is strong since a narrow pulse has a wide spectrum.
9. Applications of nonlinear optics in environmental sensing
   The devices that make use of nonlinear spectroscopy can provide additional information about our environment. One of such devices is lidar which is the counterpart of radar at optical frequency.
10. Beam shaping and conversion of laser modes
    The spatial intensity profile of a laser beam becomes important for various applications. Although Gaussian profile is applicable for general use, optical vortices or Bessel beams are desirable for some applications. There are different techniques in converting a Gaussian beam into other forms. This can be a programming project or research on various techniques.