IMR: Acquisition of an Optical Parametric Amplifier for High Magnetic Field Ultrafast Exciton Spectroscopy and Education

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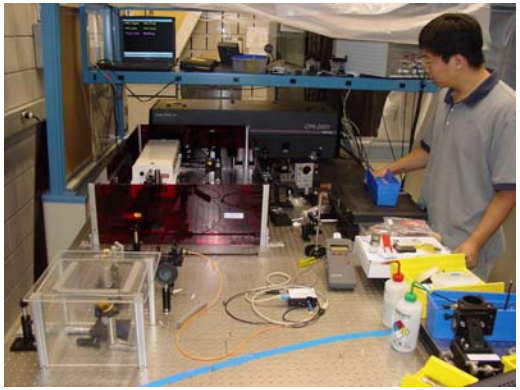
Highlights:

- Instrumentation at the NHMFL:
  - chirped pulse amplifier (CPA)
  - optical parametric amplifier (OPA)
- Capabilities
  - 150 fs time resolution, 0.06 – 4.0 eV energy scales, 4.2 – 300 K, up to 25 T fields
- New Laboratory Under Development
  - NHMFL committing funds to construct dedicated "ultrafast and infrared optics lab"
- Human Resources
  - Univ. of Florida
    - Mr. Xiaoming Wang (graduate student) and Dr. Young-Dahl Jho (postdoctoral associate) permanently based at NHMFL
  - Rice
    - Sasa Zaric, Gordana Ostojic (graduate students), Dr. Giti A. Khodaparast (postdoctoral associate) frequent visitors

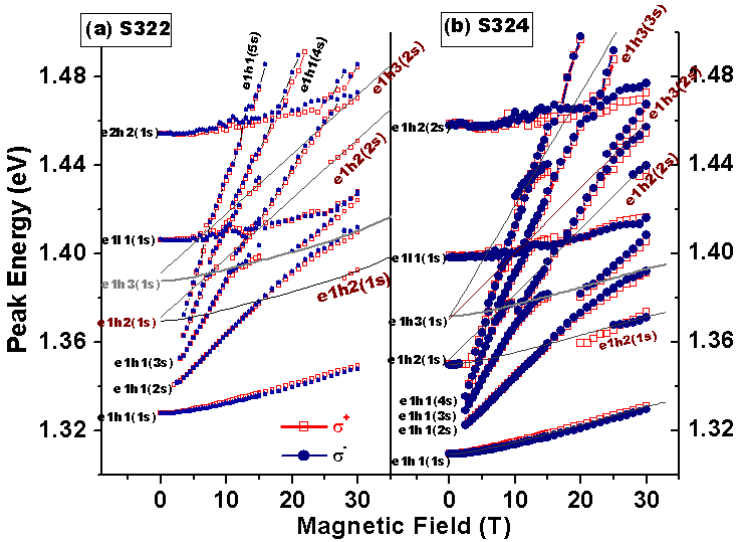
Dr. Young-Dahl Jho performing final alignment before injecting the pump and probe beams into the bore of a 25T magnet.

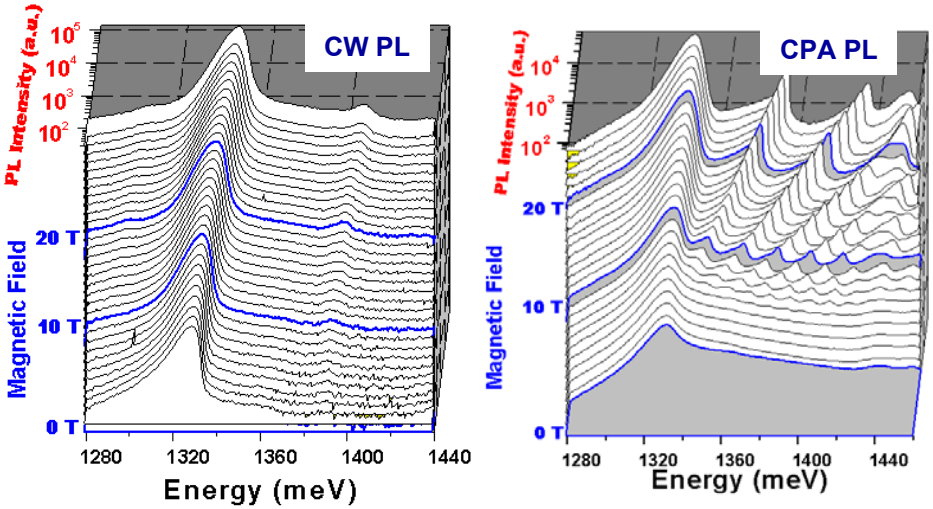


Mr. Xiaoming Wang using the CPA/OPA system in ultrafast optical studies of excitons in semiconductors.

Highlights of Rice-UF IMR 2002-2003

Observation of Bright-Dark Mixing of Magneto-Excitons - We have observed an anti-crossing behavior when a forbidden ("dark") exciton state meets an allowed ("bright") exciton state in undoped InGaAs quantum wells in high magnetic fields. The figure to the left shows appearance of 'dark states' above 10 T. The mixing between these states cannot be explained from valence band complexities. Rather, it is a manifestation of a new kind of *Coulomb-interaction-induced* mixed magneto-exciton states. (Theoretical computations performed by Prof. C. J. Stanton's group at the Univ. of Florida)



Magneto-Photoluminescence from Highly Excited Quantum Wells - We have used the CPA and OPA for magneto-photoluminescence studies of undoped InGaAs quantum wells in high magnetic fields. Due to the extremely high intensities of the CPA and OPA, we are able to probe properties of highly energetic electron-hole pairs in quantizing magnetic fields.

The figures to the right show both linear 632 nm ("CW PL") and 775 nm fs-pumped ("CPA PL") magneto-photoluminescence from undoped InGaAs quantum wells from 0 to 25 T at the same average powers. The dramatic difference in the PL spectra and the appearance of multiple Landau levels in the CPA-pumped case may arise from the inability of hot carriers to relax and scatter during the pump pulse.