TIME RESOLVED SPECTROSCOPY FACILITY FOR THE STUDY OF NONLINEAR OPTICAL PROPERTIES OF POLYMERS AND ORGANICS

A J Heeger

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Time Resolved Spectroscopy Facility for the Study of Nonlinear Optical Properties of Semiconducting Polymers

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Approved for public release
Distribution Unlimited
Our picosecond transient spectroscopy facility is in full operation with sub-picosecond pulses (autocorrelation pulses yield about 300 femtosecond pulse width). Pump/probe measurements of photoinduced bleaching, four-wave mixing experiments and third-harmonic-generation experiments are underway.

The items purchased are outlined as follows:

**ND-Yag Laser System**

Price includes:

- Autocorrelator
- Oscilloscope and Accessories
- Chopper and Accessories
- Nonlinear Crystal for Difference Frequency Generation
- Closed Circuit Camera System (Black and White)
- Misc. Optical Components (i.e. Power Meter, Beam Steering, Lab Jack, X-Y Stage, Mirrors, Mirror Mounts, Prism, etc.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
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<tbody>
<tr>
<td>ND-Yag Laser System</td>
<td>$109,292</td>
</tr>
<tr>
<td>Laser Head, Power Supply, Frequency Doubler, Mode Locker System, Mode Locker Stabilizer, Pulse Compressor, Dye Laser and Accessories, Cavity Dumper, Power Supply and Electronic Chassis</td>
<td>9,381</td>
</tr>
<tr>
<td>Oscilloscope and Accessories</td>
<td>18,503</td>
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<tr>
<td>Chopper and Accessories</td>
<td>2,338</td>
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<tr>
<td>Nonlinear Crystal for Difference Frequency Generation</td>
<td>2,041</td>
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<tr>
<td>Closed Circuit Camera System (Black and White)</td>
<td>3,219</td>
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<td>Misc. Optical Components</td>
<td>3,976</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$148,750</strong></td>
</tr>
</tbody>
</table>

**RECENT RESEARCH RESULTS**

**ANISOTROPY OF \( \chi^{(3)} \) IN A DEGENERATE GROUND STATE POLYMER: TRANS-(CH)\(_x\)**, M. Sinclair, D. Moses, and A.J. Heeger

We have measured the third order susceptibility associated with frequency tripling the fundamental of a Nd:YAG laser in various samples of polyacetylene. By measurement of the amount of third harmonic power reflected from a trans-polyacetylene sample relative to that from a sample of intrinsic silicon, we have determined the magnitude of \( \chi_{y}^{(3)} \) (all indices parallel to the chain direction) to be \( \chi_{y}^{(3)} = 9.45 \times 10^{-10} \) esu. Studies on
oriented samples indicate that $\chi_{iii}^{(3)}$ dominates all other components of the $\chi_{II}^{(3)}$ tensor, consistent with the large nonlinear susceptibility being due to the conjugated $\pi$-electron backbone. We have also measured third harmonic generation in cis-rich polyacetylene samples. Here we find that the third harmonic power scales with the residual trans content; i.e. for a sample which $\sim$15% trans, we find the measured $\chi(3)$ to be 15% of the $\chi(3)$ for the fully isomerized trans sample. Hence $\chi(3)$ for the trans isomer is more than an order of magnitude larger than that of the cis isomer. This symmetry specific aspect of $\chi(3)$ implies a mechanism which is sensitive to the existence of a degenerate ground state, as in trans-(CH)$_x$, consistent with the virtual generation of nonlinear solitons as the principal source of the large measured third order nonlinear optical coefficient of polyacetylene.
A schematic diagram of the operational facility is as follows:

[Diagram of operational facility with labels for Drive, Multichannel Analyser, Lock-In Amplifier, Index, Signal, Delay, Sample, Detector, Polarization Rotator, Beam Splitter, Probe, Chopper, Laser, and Reference.]
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