**205Tl setup on INOVA-500**

cgfry: 13 April 2007

**Introduction**

Thallium and $^3$He are unique in having resonance frequencies that falls between $^{31}$P and $^{19}$F. On a 11.74 Tesla magnet:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Spin</th>
<th>Natural Abund. %</th>
<th>Freq (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{31}$P</td>
<td>1/2</td>
<td>100</td>
<td>202.5</td>
</tr>
<tr>
<td>$^{203}$Tl</td>
<td>1/2</td>
<td>29.5</td>
<td>285.8</td>
</tr>
<tr>
<td>$^{205}$Tl</td>
<td>1/2</td>
<td>70.5</td>
<td>288.6</td>
</tr>
<tr>
<td>$^3$He</td>
<td>1/2</td>
<td>0</td>
<td>381.0</td>
</tr>
<tr>
<td>$^{19}$F</td>
<td>1/2</td>
<td>100</td>
<td>470.6</td>
</tr>
<tr>
<td>$^1$H</td>
<td>1/2</td>
<td>99.98</td>
<td>500.2</td>
</tr>
</tbody>
</table>

For electronic reasons, commercial spectrometers are built such that $^{31}$P is the highest frequency X nucleus, and $^{19}$F is the lowest of a narrow band providing for it and $^1$H.

To observe $^{205}$Tl (with $^{203}$Tl obviously being very similar, only having a lower sensitivity due to its lower natural abundance), there are three broad areas of a commercial spectrometer that must be considered for potential modification:

A. A probe must tune to the $^{205}$Tl frequency, 288.6 MHz for a 14T magnet. Commercial broadband probes typically will not tune on the X channel more than a few MHz above $^{31}$P. We have taken an older broadband probe, and tuned the X channel up to 288.6 MHz. Modification of a triple resonance probe (with 3-channel spectrometer) would be required to enable $^{205}$Tl{$^{31}$P,$^1$H} experiments.

B. The transmitter chain must generate high-power rf pulses at the $^{205}$Tl frequency. Frequency synthesis is typically not a problem, but 220 or 250 MHz is often the limiting upper frequency for broadbanded power amplifiers. Fortunately, our INOVAs 1H cover 200-500 MHz, allowing $^{205}$Tl rf to be generated. Filtering must be adjusted to allow $^{205}$Tl, and reject other (e.g., decoupler) frequencies.

C. The receiver chain must have good low-noise preamplification at $^{205}$Tl frequency, with demodulation at that frequency. Preamplifiers often cutoff around 250 MHz. The INOVA X preamp can handle the $^{205}$Tl frequencies, but the transmitter and LO (for demodulation) must be properly routed; both cabling and software control must be properly setup.

Requirements for B and C will be console/hardware dependent. The next section describes changes that enable the experiment on our INOVA-500 spectrometer.
Implementation on the INOVA-500

Our hardware specifications are:

INOVA-500
Amp: AMT 3900A-12
Varian PN: 00-969441-03
ch A 200-500 MHz
ch B 6-220 MHz

1. Move 1H cables on 1H/19F preamp to the X preamp (check that all cables are properly labeled before doing this).

2. Move white (LO) cable from 1H/19F preamp to the X preamp. To get the cable to reach, unscrew and lift the X preamp off the mounting slide screws, and carefully lay the X preamp on the floor in reach of the 1H white cable.

3. Had to remove all bandpass filters, so X preamp cable went straight into the probe (we will have to look for a proper low-reject or bandpass when doing 31P decoupling; multiple serially in-line filters might work better if rejection is <60dB per filter).

4. Had to remove the high-pass filter off the proton xmitter cable at the back of the main (air-pneumatics/switching) box next to the magnet; this filter rejects everything < 350MHz.

5. create('amphbmin','real','global')
   amphbmin=280

   pw90=22us at tpwr=63 on an old broadband probe.

Note that the probe will have a finite bandwidth, as will a reasonably sized pulse width. Assume < 200 kHz. A larger change while searching for the signal requires the probe be retuned to the new center frequency.

On the 500, Tl205 will be 2.8MHz downfield from Tl203.