ALEXANDRITE LASER SOURCE FOR ATMOSPHERIC
LIDAR MEASUREMENTS

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During the past years, there has been a marked increase
in interest in the applications of vibronic solid-state lasers
to meteorology and atmospheric physics. Two airborne lidar
programs are now under development in France at CNRS and CNES,
in addition to preliminary studies of future lidar applications
from space platforms.

The differential absorption lidar (dial) method with
vibronic solid-state lasers is very attractive for water vapor,
temperature and pressure measurements (1), (2), (3). Alexandrite
laser and titanium-sapphire are both suitable for these applica-
tions. However, only Alexandrite rods are commercially available
to day.

The requirements on the laser source for airborne dial
applications are two-fold: i) a restriction on laser linewidth
and a requirement on stability and tunability with a good spec-
tral purity; ii) a requirement on the time separation between
the two pulses. These constraints are summarized in table 1. In
addition a laser energy of 50 to 100 mJ and a 5 to 10 Hz pulse
repetition frequency are also required.

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<th>H2O</th>
<th>p,T</th>
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<tbody>
<tr>
<td>emission wavelength</td>
<td>725-732 nm</td>
<td>760-770 nm</td>
</tr>
<tr>
<td>spectral width</td>
<td>1 pm</td>
<td>0.3 pm</td>
</tr>
<tr>
<td>spectral wavelength separation</td>
<td>70 pm</td>
<td>70 pm</td>
</tr>
<tr>
<td>temporal wavelength separation</td>
<td>100-400 µs</td>
<td></td>
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<tr>
<td>spectral purity</td>
<td>99 %</td>
<td></td>
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</table>

Table 1

A dual wavelength double pulse oscillator is very attrac-
tive with respect to weight, electrical power and volume for fu-
ture lidar emissions. Such a configuration is under development
in our French laboratory and preliminary results have been
obtained using a double Q switching with an acousto-optic devi-
ce. We did demonstrate a broadband double-pulse operation of
approximately 50 mJ in each pulse for a pulse separation of
100 µs. The total energy of 100 mJ for 140 J is slightly lower
than the 110 mJ for a single Q-switching after 250 µs. The
total energy extracted after 180 µs is maximum for a 90 µs delay
between pulses (figure 1).
Figure 1: Total output energy of the double pulse broadband oscillator as a function of the delay between the two emitted laser pulses.

In a separate work a narrow line single pulse emission has been obtained using a new cavity arrangement: the output coupler of the broadband cavity is replaced by an auxiliary cavity made of a diffraction grating G at grazing incidence in conjunction with two mirrors (figure 2).

Figure 2: Synoptic diagram of the narrow band Alexandrite oscillator.

A dual-mode laser emission (equivalent linewidth of 0.5 pm) is observed when the auxiliary cavity length is reduced to 9.3 cm total and when the grating is set at a grazing incidence angle of 88°. The laser mode separation recorded with the Fizeau
interferometer is 0.27 pm. It is in agreement with a value of 0.29 pm calculated from the main resonator cavity length. A strong modulation of the pulse envelope is also observed due to mode beating (fig. 3b). The output energy is 20 mJ (for an input of 180 J). We also observed a quasi-single mode emission (fig. 3c), with a smooth temporal envelop. In this case the observed mode linewidth is 0.14 pm (75 MHz) which corresponds to an experimental finesse of the Fizeau interferometer equal to 17. This value is in agreement with an apparatus function determined by a reflective finesse of 38, a defect finesse of approximately 25 and the number of successive reflections which reduces the experimental finesse at a value smaller than the expected theoretical limit.

Future works including a dual wavelength double pulse transmitter which is a follow-on of our previous developments on a laser pumped dye (4) will be discussed.

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Figure 3: Bimodal laser emission as recorded a) by a Fizeau interferometer with a 12 cm spacing between plates ($\delta\lambda = 2.3$ pm between consecutive orders) b) by a fast photodiode (temporal beating)

References
