P1-8 Lidar Observations of Mesospheric Ionic Calcium Layer with a Flashlamp Pumped Ti: Sapphire Laser

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A Titanium-doped sapphire ($Ti:Al_2O_3$) laser has a very wide tuning range from 700nm to 1000nm. Usually, Ti:sapphire pulse lasers are pumped by frequency doubled Nd:YAG lasers, and the tunable laser systems become complicated considerably because they need to prepare the oscillator-amplifier systems to get the large energy. The flashlamp pumped Ti:sapphire laser with solid-state fluorescence conversion, cw-simmer and prepulse technique achieves the high efficient and simple system.

We are developing the resonance scattering lidar system for measurement of mesospheric metallic atoms and ion such as K, Fe, Ca^+ and so on. It is necessary for the resonance scattering observation to lock the laser wavelength at the resonance wavelength and to reduce the linewidth of the laser. For locking the laser wavelength and spectral narrowing of the laser line, we adopt the injection seeding technique. Injection seeding has the merit that the internal loss of the laser cavity is smaller than any other methods. So, we have developed the injection laser that consists of a external cavity laser diode (ECLD) and constructed the flashlamp pumped Ti:sapphire laser seeded by the ECLD (Kyomitsu et al., 1998). It is possible to lock the wavelength of the injection laser to the center of the resonance line by feedbacking the optogalvanic signal from target atoms to the ECLD.

The laser is based on a commercial flashlamp pumped Ti:sapphire laser (Elight Laser Systems, Ti:Flash series). The Ti:sapphire rod (8 x 150 mm; doped with 0.1 wt.% Ti) was pumped by three flashlamps driven by a 2 kW power supply. A multistep simmering circuit was used to reduce the discharge duration in the lamps and extend their lifetime. The schematics of the laser are shown in Figure 1. The linewidth (FWHM) of the flashlamp pumped Ti:sapphire laser with injection seeding was 0.55 pm. The output power was about 35 mJ at 770 nm, and the pulse width was about 50 ns. The laser output of the second-harmonic wavelength is obtained using a angle-tuning LBO crystal. The tuning curve of the second-harmonic wavelength is shown in Figure 2.

Using the fundamental wave of the laser, the potassium lidar observation has performed at the campus of Tokyo Metropolitan University. Final laser pulse energy was about 35 mJ and the repetition rate was 10 Hz at 769.89 nm of the resonance line of the potassium. The receiver has the diameter of 350 mm and the field of view of 1mrad. The observed density profile of potassium atoms is plotted in Figure 3. Each profile is derived from the photon count accumulated from 36000 laser shots. The potassium layer at 80-110 km altitude was evident clearly and the peak density of the potassium atoms was 25 cm^{-3} at 93 km.

The sporadic Na layers had been observed commonly at low- and high-latitude sites but rarely observed at mid-latitude sites. But we had observed a lot of sporadic Na layers over our site at mid-latitude (Nagasawa and Abo, 1995). We also suggested the close relations between sporadic Na layers and ionospheric sporadic E layers statistically. We will try to clarify this relationship experimentally by simultaneous observations of ionic and atomic layers.Same approach was made using a dye laser (Alpers et al.,1996), but not made at mid-latitude site where sporadic Na layers are frequently observed. Calculated error of ionic calcium measurement is shown in Figure 4. It is assumed that the laser wavelength is 393nm, energy is 10mJ, repetition rate is 10 Hz, accumulation time is 10 min, telescope aperture is 60 cm, and range resolution is 200 m. The ionic calcium density is assumed Gaussian profile using column abundance of $4x10^8$ cm^{-2}, rms width of 4 km and centroid height of 98 km. We will detect the ionic calcium layers within 10 % error when the peak density of the ionic calcium is over 400 cm^{-3}.

References

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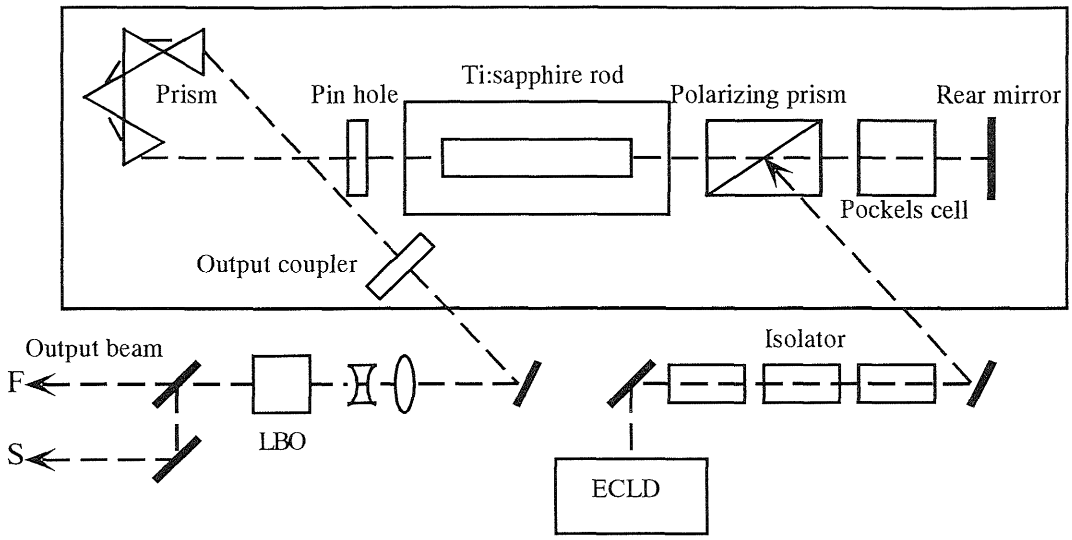

Figure 1. The schematics of flashlamp pumped Ti:sapphire laser seeded by a external cavity laser diode.

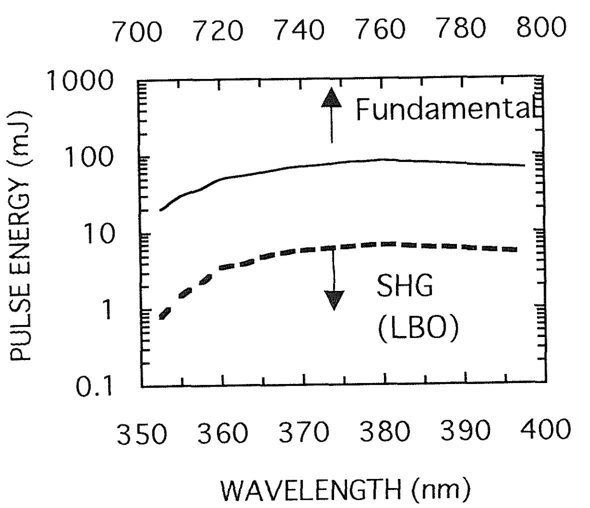

Figure 2. The tuning curve of the second-harmonic wavelength.

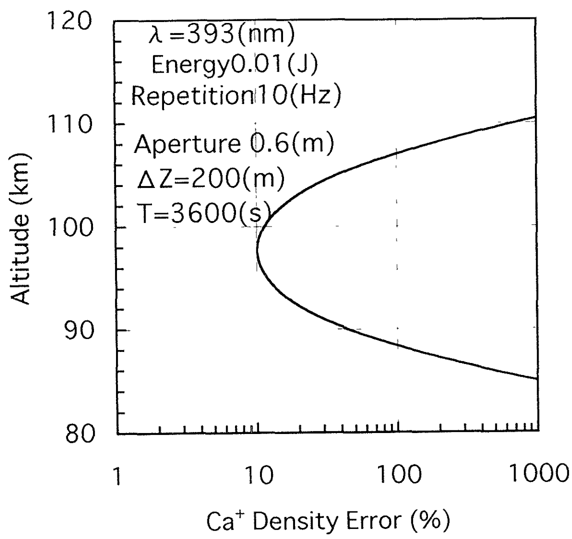

Figure 4. Calculated error of ionic calcium measurement.

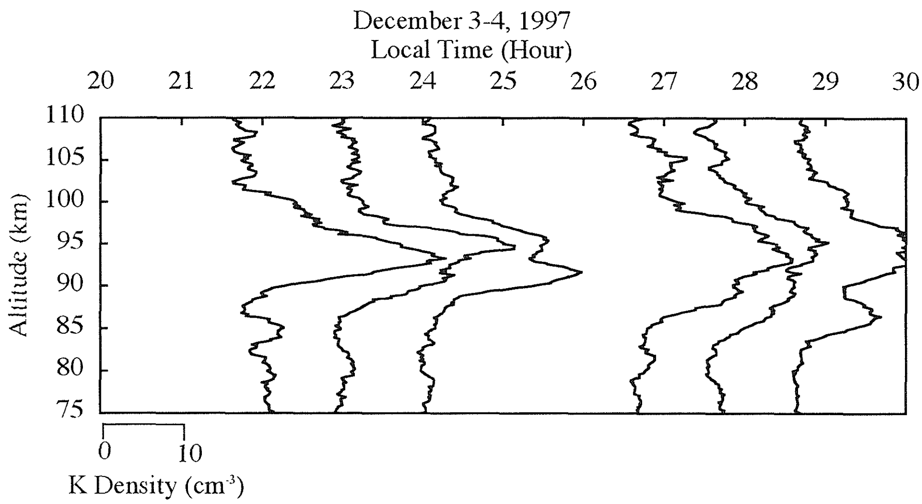

Figure 3. The observed density profile of potassium atoms.