Receiver of a Mobile Direct-detection Doppler Wind Lidar

Jiqiao LIU, Lingbing BU, Jun ZHOU, Ting YU, Weibiao CHEN

Shanghai Institute of Optics and Fine Mechanics , CAS, Shanghai, P.R.China, Email:siomll@hotmail.com

ABSTRACT

An eye-safe mobile direct-detection Doppler wind lidar employing the fringe imaging technique and the double-edge technique simultaneously is being developed in Shanghai. The two methods will be compared and validated. The lidar receiver consists of a mutli-beam Fizeau interferometer (MFI) and a double Fabry-Perot interferometer (DFP), which measure wind profiles in the planet boundary layer(PBL) and the upper troposphere respectively. Wind velocity accuracy simulation is implemented, and it shows this instrument will have good performance to measure wind profile. Experiments are being done to evaluate its measurement capability.

INTRODUCTION

Wind velocity measurements are essential to understand global circulations of carbon, water and energy. The World Meteorology Organization (WMO) also requires accurate global troposphere wind profiles to enhance the climate study and operational weather forecast. Doppler lidar is proved as an effective tool to measure three-dimensional wind speed with high accuracy[1]. The Doppler shift can be measured by either direct-detection or coherent techniques. Direct detection has merits on global wind measurements[2]. Direct detection techniques fall into two categories: edge techniques[3] and fringe-imaging techniques[4]. Both of them are thought to have almost the same wind accuracy[5]. A mobile direct-detection Doppler wind lidar is being developed, which utilizes both two techniques to measure wind profile in different altitude. The instrument is described below. The wind accuracy is analyzed with the two Doppler frequency discriminators .

INSTRUMENT DESCRIPTION

A mobile Doppler wind lidar is under construction. Fig.1 shows the simple instrument layout. The transmitter is an injection-seeded diode-pumped Nd:YAG laser, frequency tripled to 355nm, which is the promising candidate for a direct-detection Doppler lidar. Transmitter and receiver system are coaxial. Table 1 shows the parameters of our Doppler lidar system. The Cassegrain telescope receives atmosphere backscattering light ,then coupled to Doppler shift analyzers by a silica fiber. Partial outgoing laser is introduced as reference light with null Doppler shift through a reference fiber to the interferometers. In the PBL the aerosol backscattering signal is analyzed by MFI. The linear fringe of MFI is imaged on the 16 channels Hamamatsu R5900U PMT arrays to derive wind speed. DFP interferometer is employed to measure the troposphere wind velocity from atmosphere molecules Rayleigh scattering signals. The two interferometers are separated by a polarization switch. The temperature inside the interferometers chamber is kept above room temperature and can be maintained within ±0.005ºC. An energy monitor is used to adjust the optical axis of receiver telescope and transmitting laser. It can also provide normalized signal for molecular channel. Four points conical scanning will be implemented to acquire horizontal wind vector.

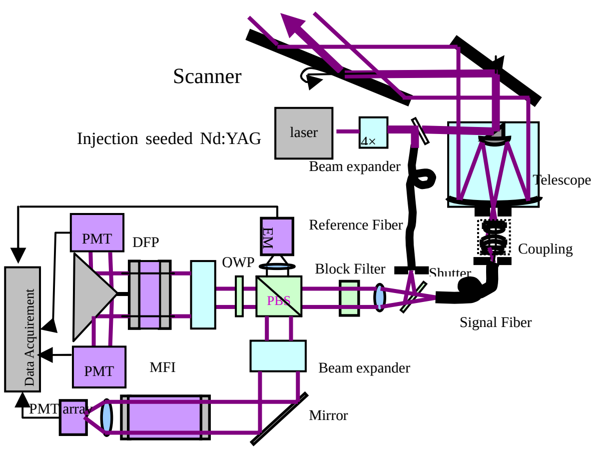

Fig. 1 Block diagram of direction detection Doppler lidar

Table 1. Parameters of direct-detection Doppler lidar

Items	Parameters
Wavelength	355 nm
Energy	30 mJ/pulse
Line width（FWHM）	<200 MHz
PRF	100Hz
Pulse duration	<20ns
Zenith angle	48º
Telcescope diameter	400mm
FOV	0.3mrad
Blocking filter linewidth	0.35nm
MFI FSR	1GHz
MFI linewidth	~0.1GHz
DFP FSR	12GHz
DFP offset	~5.2 GHz
DFP linewidth	~1.6GHz
PMT	20％
PMT array	20%(16 channels)

NUMERICAL SIMULATION

The lidar receiver parameters are optimized to measure wind profile according to the requirements of meteorology with normal horizontal wind error and altitude resolution. MFI and DFP etalons are built to in the light of optimal measurement sensitivity. The atmosphere models are selected based on NASA atmosphere standard. The aerosol scattering profile exploits enhancement atmosphere model . The molecular scattering profile is due to standard atmosphere model. The altitude resolutions in the PBL and troposphere are 200m and 1000m respectively. The simulated horizontal wind error profiles are given in Fig.2. It shows that horizontal wind errors are limited to 1m/s in PBL and 3m/s in troposphere.

CONCLUSIONS

The lidar receiver employing two direct-detection techniques is described. The simulated wind profile measurement accuracy is given, which shows good performance. Now a mobile Doppler lidar is assembling. In the near future wind velocity measurement with two frequency discriminator will be validated.

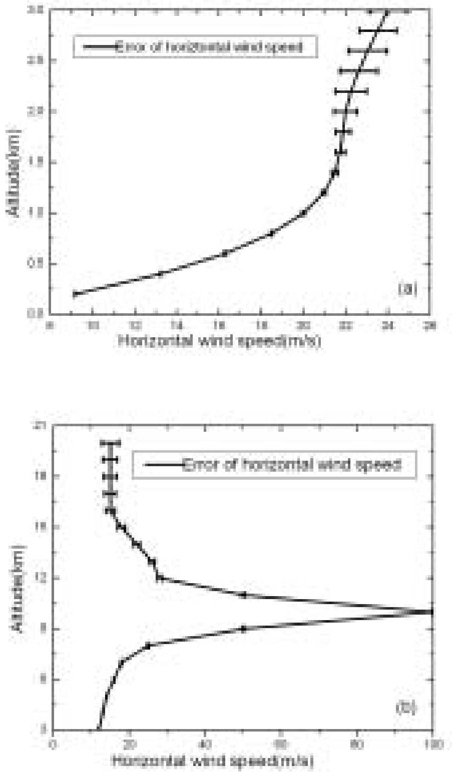

Fig.2 Simulated error of supposed wind profile (a)MFI with 200 pulses averaged and (b)DFP with 6000 pulse averaged.

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