25B1 **LIDAR ACTIVITY IN CHINA**

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The invention of the laser began a new era for monitoring of atmosphere. In China, first lidar was established in 1965. Since then, many kinds of lidar have been constructed. These lidars are used in the following measurements: stratospheric aerosol and ozone profile, tropospheric aerosol (smoke plume density, aerosol extinction coefficient, yellow-sand-storm, and water vapor), Sodium layer and Rayleigh scattering in middle atmosphere, sea water temperature and oil slicks on sea surface etc. Meanwhile, Chinese scientists also pay their attention to the methodologies of lidar measurements.

I. STRATOSPHERIC AEROSOL PROFILE AND VOLCANIC CLOUD

In order to understand the effects of volcanic activities on climatic change, it is important to know the extent of the temporary variation and the vertical distribution of stratospheric aerosol. A ruby lidar was completed by Mrs. Y. Zhao's group at Institute of Atmospheric Physics (IAP), Beijing, in 1965. It contains a Q-switched ruby laser with 1 Joule per pulse, and a 40cm diameter receiving telescope. The lidar was used to measure both El Chichon, and Pinatubo volcanic cloud[1,2] over Beijing (39°54'N, 116°27'E). The IAP's ruby lidar was removed to Chinese Zhongshan Station in the Antarctic in March of 1993 to monitor the antarctic stratospheric aerosol. A large scale lidar,called L625 lidar[3], was constructed by Dr. H. Hu's group at Anhui Institute of Optics and Fine Mechanics (AIOFM) in 1990. The L625 lidar(YAG, 532nm, 100mJ/pulse, 625mm aperture receiving telescope, and a photon counter with 100MHz) has been running routinely at Hefei (31°54'N, 117°10'E) since January of 1991. The 285 lidar measurements of Pinatubo volcanic cloud were taken between June 1991 and February 1994. The data provide the variation details of the volcanic cloud[4,5].

II. MEASUREMENTS OF STRATOSPHERIC OZONE

The lidar measurements of stratospheric ozone have been carried out in China. A DIAL lidar was established by Dr. Hu's group at AIOFM in 1993. It contains an excimer laser of XeCl (400mJ/pulse, 25Hz) with 308nm wavelength (on-absorption) and the third harmonic of Nd:YAG laser (80mJ/pulse, 5-10Hz) with 355nm wavelength (off-absorption). The profiles of ozone density, from 15km to 40km, have been obtained by the lidar at Hefei since Dec. 28th, 1993. The stratospheric ozone profile will be measured continually by the DIAL lidar.

It is important to eliminate the aerosol effects on the accuracy of DIAL measurement of ozone, especially during volcanic period. A Dual-DIAL technique has been proposed by Z. Wang[6] . According to the numerical experiments, the influence of volcanic stratospheric aerosol may be decreased 5-10 times by using the technique. An inversion technique of three-wavelength lidar (532nm, 355nm, and 308nm) was proposed by J. Qiu[7] for a better simultaneous determination of ozone profile, aerosol backscattering coefficient profile and its size distribution in stratosphere.

III. LIDAR MEASUREMENTS IN THE TROPOSPHERE

The lidar technique is feasible and useful for monitoring the troposphere, such as plume dispersion, aerosol extinction coefficient, cloud base height, horizontal and slant visibility, and water vapor.

Accurate and automatic Runway Visual Range (RVR), Slant Visual Range (SVR), and Cloud Base Height (CBH) sounding are very important for safe airplane landing and take-off at airports. A primary experiment of SVR lidar sounding was successful at an airport near Beijing in 1977[8] . Then, a new YAG lidar was completed for the same purpose in 1991. Experiment results[9] show that the lidar's accuracy in RVR, SVR, and CBH sounding can meet the needs of weather and aviation safety. A large amount of atmospheric extinction coefficient profiles was measured in different seasons by using a lidar at Beijing [10]. The yellow sand storm, a kind of strong Spring dust storm, comes from Loess Plateau, passes Beijing and then can be transported, sometimes, to Japan or further. The data of vertical profile of extinction coefficient, measured by the lidar at Beijing in two real severe yellow sand storms, reveal the arrival and transportation process of the dust particles[11]. A Type-III lidar (ruby laser, 0.4J, 0. 2Hz, receiving telescope of diameter 6cm) was used to measure the real plume profiles, from which the atmospheric dispersion parameters, σ_y and σ_z, were derived [12].

An electro-optically fast tuning ruby lidar was used for water vapor sounding in the atmosphere in 1983[13].

Some new lidar systems are being constructed for tropospheric measurements these years in China. For example, a mobile dual-wavelength lidar (YAG, 532nm and 1064nm) has been constructed by Dr. J. Zhou's group at AIOFM. The two-wavelength operation can provide more information of aerosol. A portable diode laser lidar is being constructed by Dr. D. Xiao's group at Chengdu Institute of Meteorology for measuring the visibility and raindrop size distribution.

IV. LIDAR MEASUREMENTS IN THE MIDDLE ATMOSPHERE

The lidar studies of the middle atmosphere is another important scientific field. There are two lidar systems for the purpose in China. A ruby lidar was constructed by Dr. Y. Wang's group at Center for Space Science and Applied Research, Beijing. It contains a ruby laser(694.3nm,7J per pulse), and a receiving telescope of diameter 1.56m. The molecule density profiles were measured by the lidar from 30km to 60km at Beijing. Another lidar is being constructed by Dr. S. Gong's group at Wuhan Institute of Physics, Wuhan, for measuring the Sodium layer. In the lidar system, a MOPO(Quanta-Ray), pumped by a YAG laser, emits the pulse energy of 30mJ at wavelength of 589nm (pulse width of 5ns, line width of 1-3 GHz).

V. METHODOLOGIES OF LIDAR MEASUREMENTS

An empirical expression for ratio k of aerosol extinction-to-backscattering was established for ruby lidar measurements by Dr. X. Zhou[14]. Dr. Jingqun Sun[15] analyzed the error in lidar measurement of the aerosol extinction coefficient due to the variations of the ratio k. An approximation lidar equation, taking consideration of double scattering, was developed by Dr. D. Lu[16] for remote sensing in low visibility condition. The imaginary part of aerosol refractive index was retrieved from the simulated double scattering signals of lidar from "blind range" [17]. Dr. J. Qiu[18] developed a parameterized multiple-scattering lidar equation and its inverse theory, which can be used to determine aerosol or cloud property from the returns. Lidar remote sensing from space is its most promising application. An inversion algorithm [19] was developed to determine atmospheric aerosol profiles from simulated space-borne lidar signals.

VI. LIDAR APPLICATION IN MEASUREMENTS OF OCEAN

The application of lidar has been developing steadily in measurements of ocean during the past decade. A Nd:YAG Raman lidar has been established for detection of the temperature profile by means of the Raman spectrum of sea water by Dr. Z. Liu's group at Ocean University of Qingdao. The accuracies of the measured temperature are 0.4°c (rms) in laboratory and 0.5°c (rms) in situ, respectively. A UV-lidar was constructed for detection of oil slicks on sea surface by Dr. Y. Xun's group at AIOFM. The oil slick can be recognized according to its laser-excited fluorescence spectrum.

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