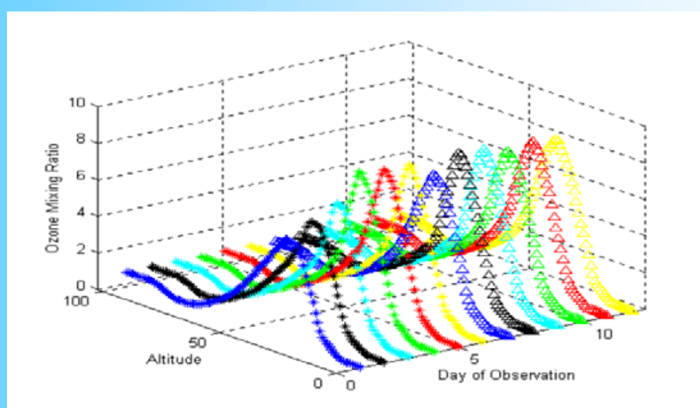
Ground-Based Microwave Observation of Stratospheric Ozone



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Jung Jin Oh
Sookmyung Women's University
Seoul, South Korea

Abstract

- The J = 6(1,5) - 6(0,6) rotational transition of stratospheric ozone at 110.8359 GHz has been observed using Schottky diode mixer receiver at Sookmyung Women's University in Seoul during Feb, 2002 by total power method.

- The instrument is a millimeter-wave receiver system based on the heterodyne principle, which is composed of an antenna, quasi-optics, SSB filter, mixer, intermediate frequency amplifiers, spectrometer, and computer. The mixer block is cooled at a temperature of 20 K by a closed cycle refrigerator of liquid He and the system temperature was determined to be about 700 K.

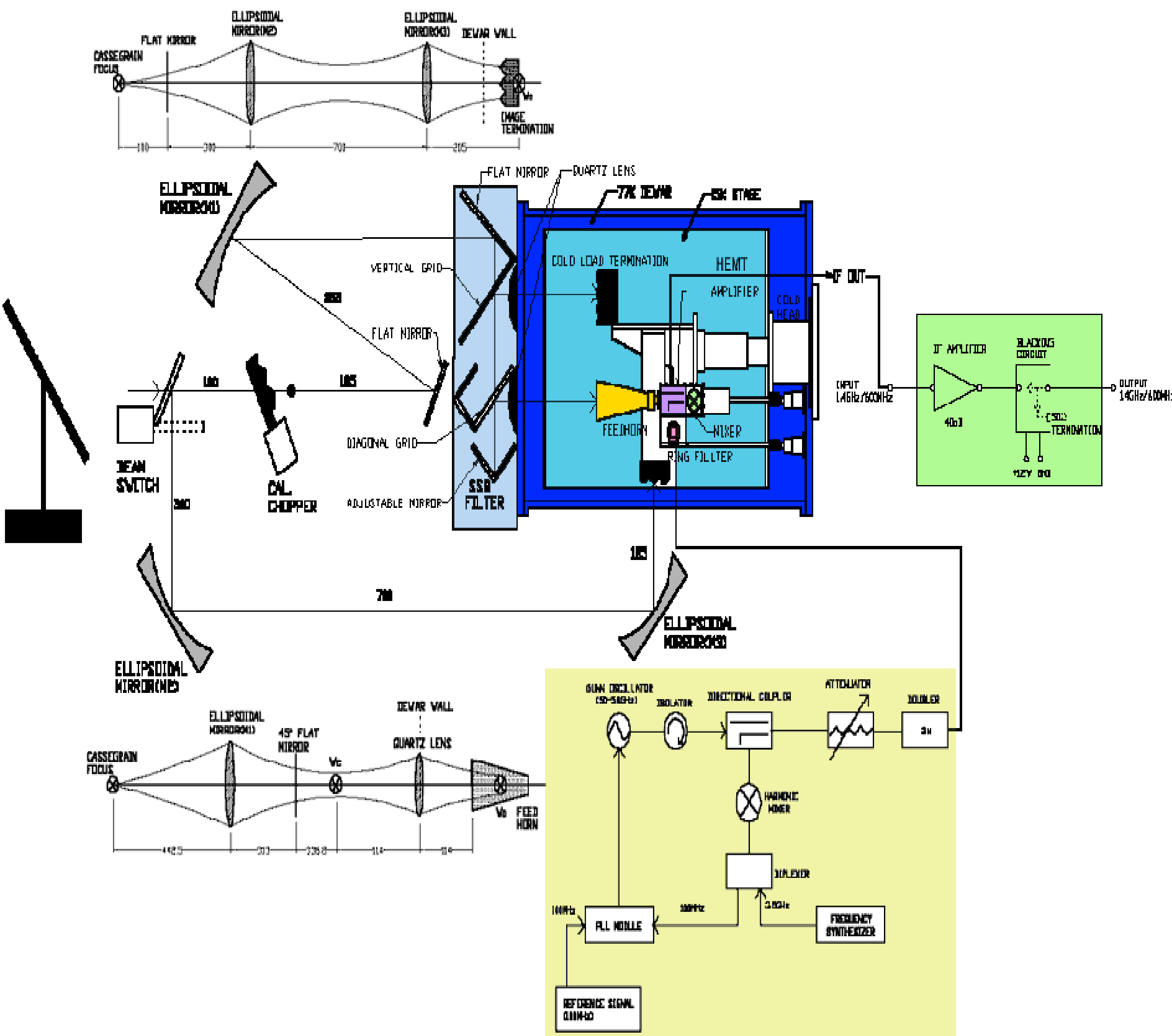
- The observed spectrum has been analyzed to determine variations in the ozone mixing ratio at various altitudes above Seoul. The retrieval algorithm used to obtain the data will be discussed and the variations of the altitude profiles are compared.

Ozone Observatory

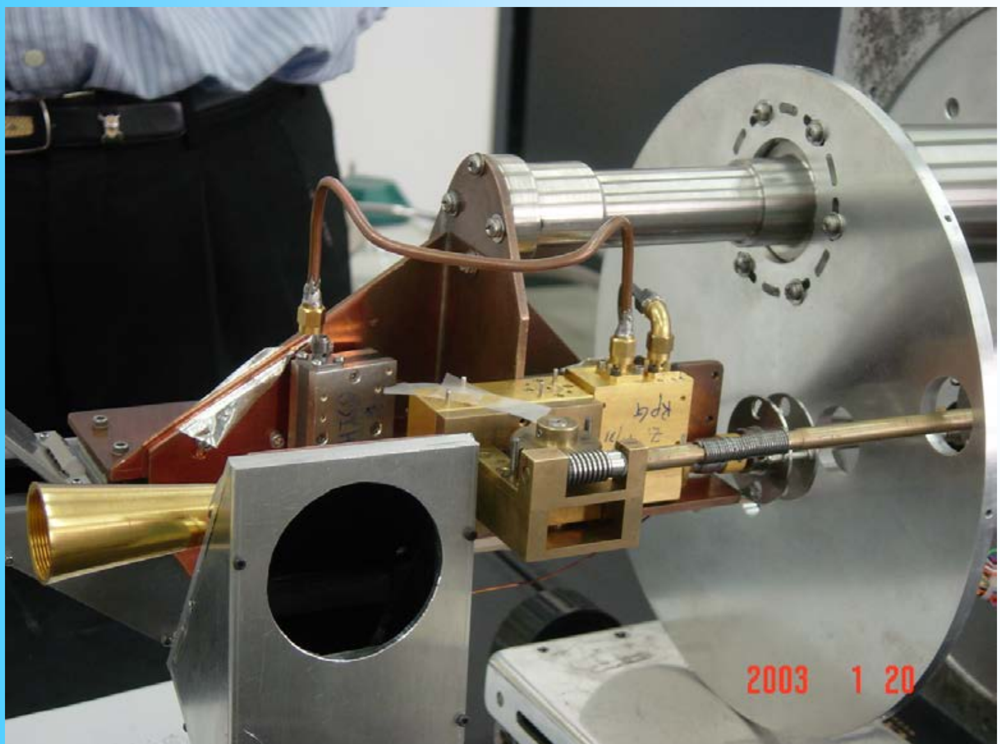
(Sookmyung Women's University)

- ***Longitude* :** **127°22' 19" E**
- ***Latitude* :** **36°23' 53" N**
- ***Altitude* :** **52 m**
- ***Location* :** **Sookmyung Women's University**
  Seoul, Korea

Scheme of the Radiometer



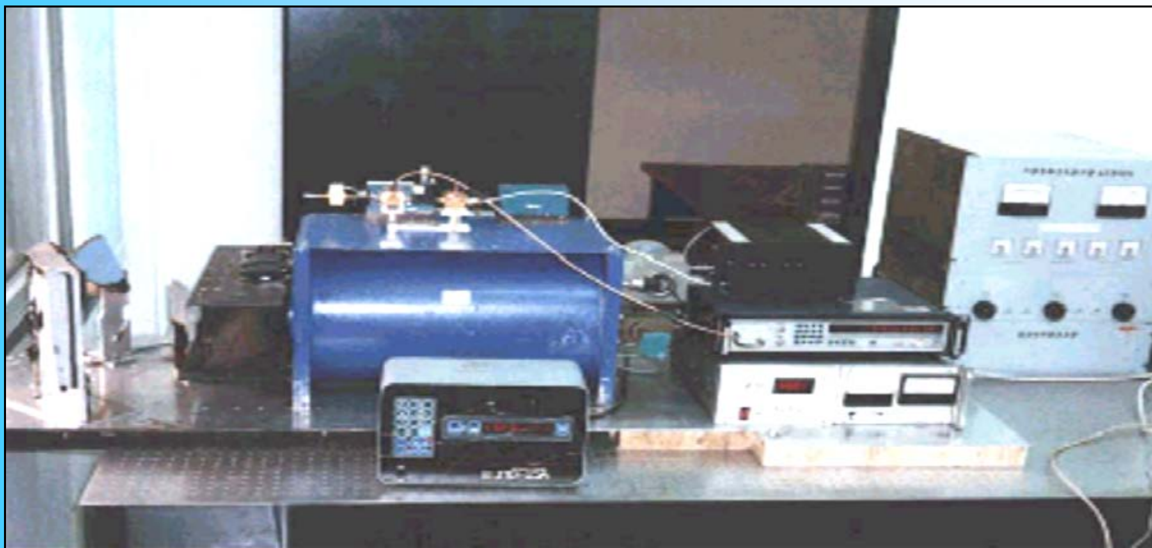
Cold Load



Seoul Ozone Radiometer System (SORAS)

- O_3 transition $6_{1,5}$ - $6_{0,6}$ at 110.8359 GHz
- Schottky diode mixer system (Millitech Co.)
  (20K Closed-loop He cryo cooler)
- Local Oscillator at 54.7 GHz and multiplier
- HEMT amplifier (20K, 30dB) and warm IF amplifier 1.4 GHz+-300 Mhz(~70dB)
- System temperature : 700K (SSB mode – Quasi Optical MPI)
- Filter Bank Spectrometer
  (TRAO 256 Channel, 64 MHz full band)
- Total power method

Millimeter Receiver



[Front - End] ***[Back - End]***

Quasi-Optics □ SBS Filter □ Dewar (1) □ IF Amp. □ Filter Bank

(1) Feed Horn □ Ring Filter (2) □ Mixer □ HEMT Amp.

(2) LO INJECTION :

Doubler □ LO Atte. □ Directional Coupler (3) □ Isolator □ Gunn Osc.(4)

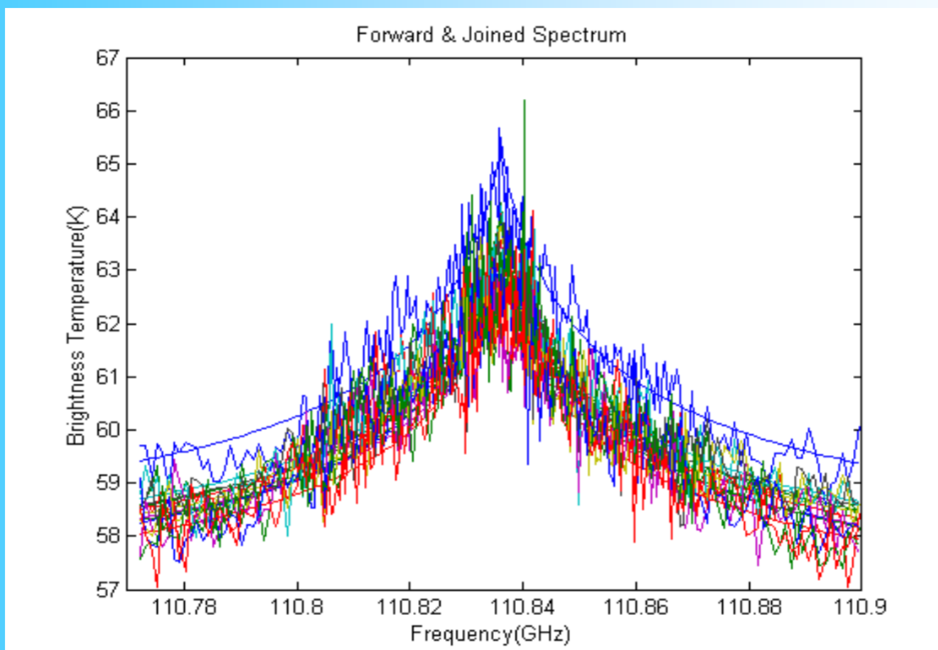
(3) Directional Coupler □ Harmonic Mixrer □ Diplexer

(4) PLL Module :

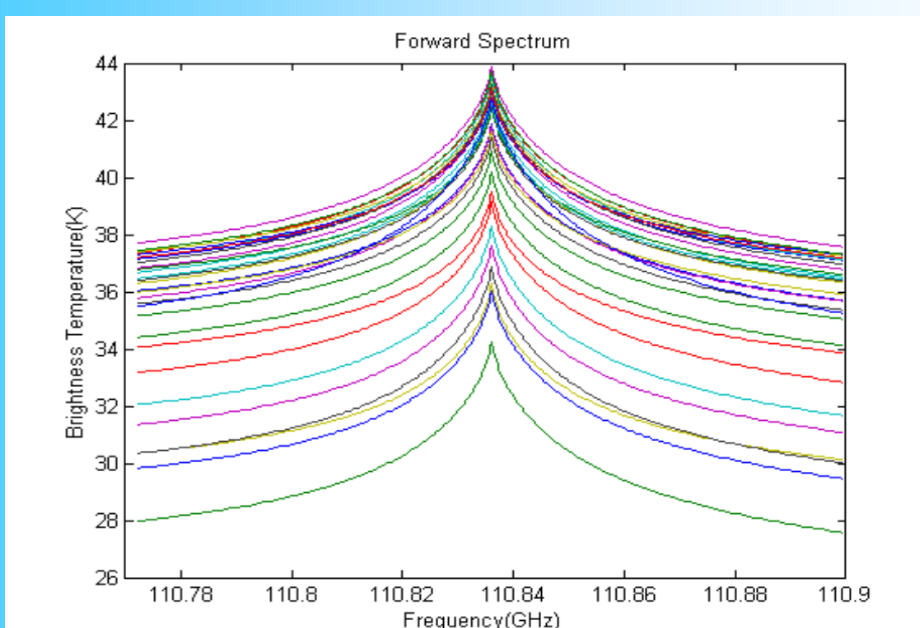
Gunn Oscillator(50~49GHz), 100MHz Reference Oscillator

Observation of Stratospheric Ozone

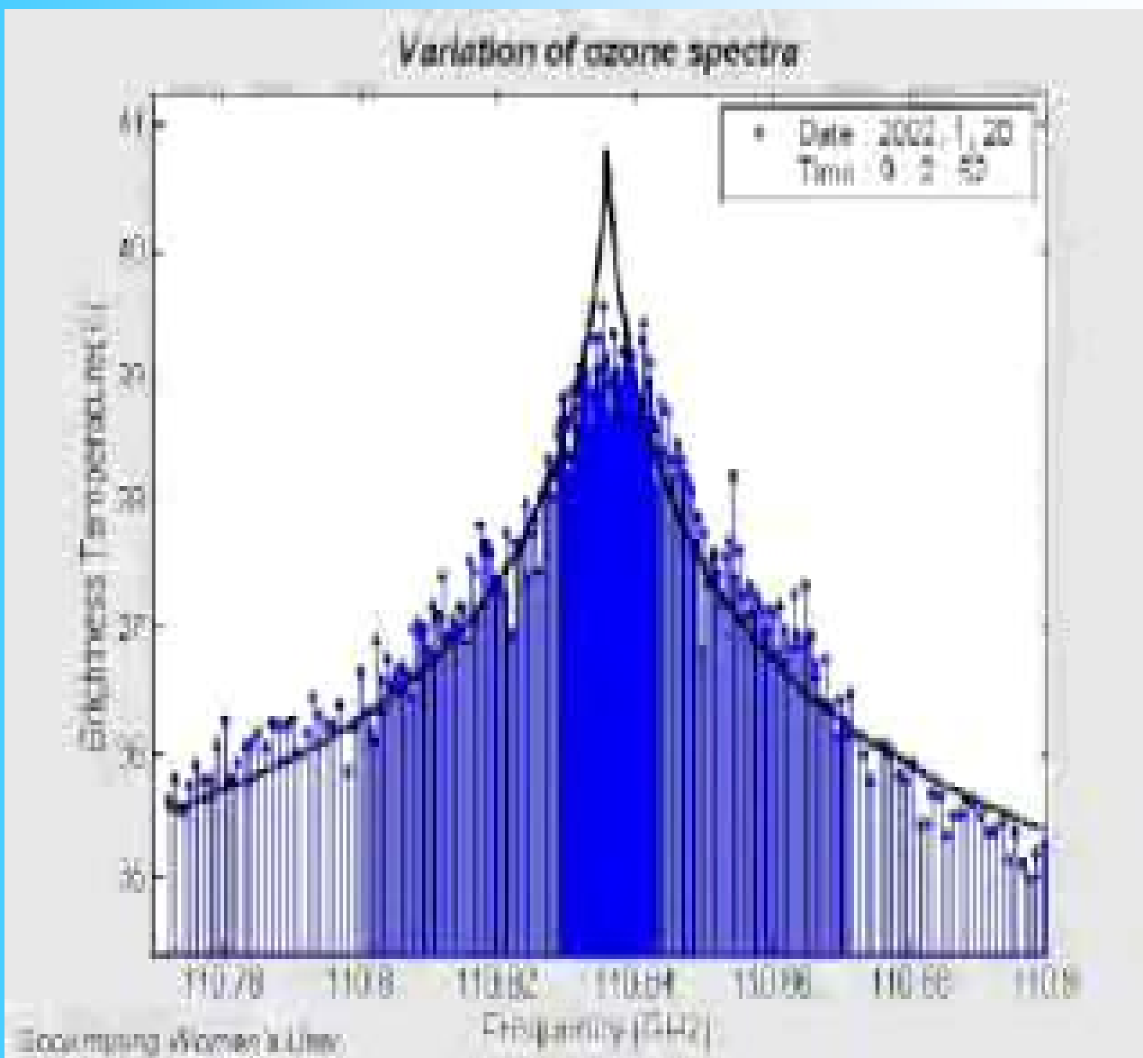
- **Typical Observed Spectra (Feb 6, 2002)**



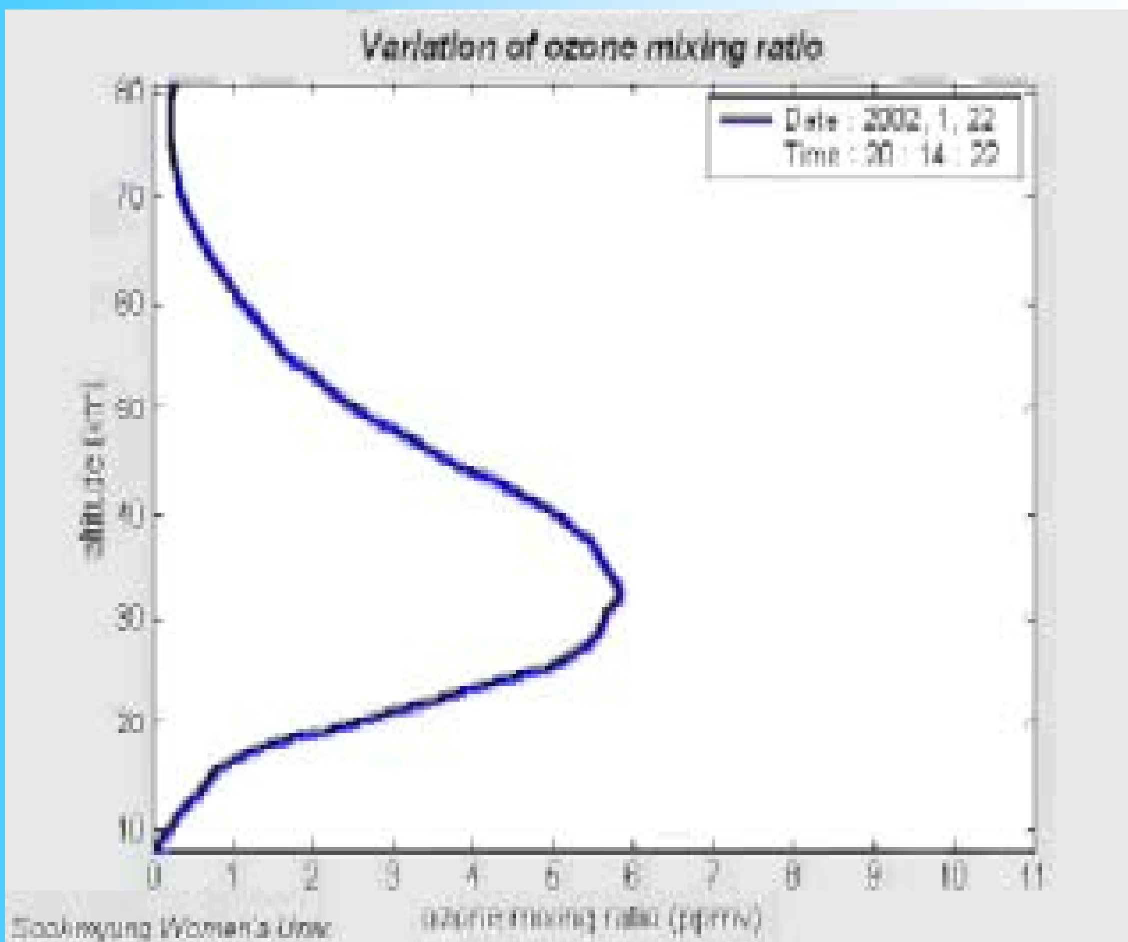
- **Typical Forward Spectra (Feb 7, 2002)**



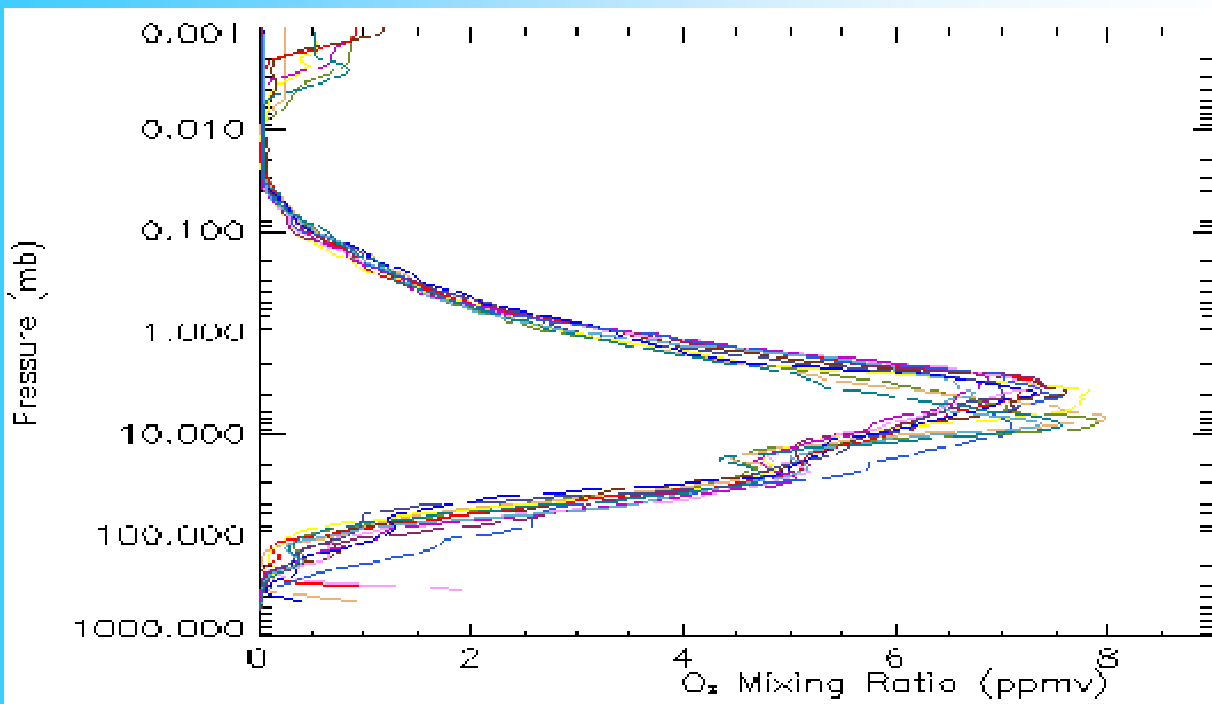
Obs. and Calc. Ozone Spectrum

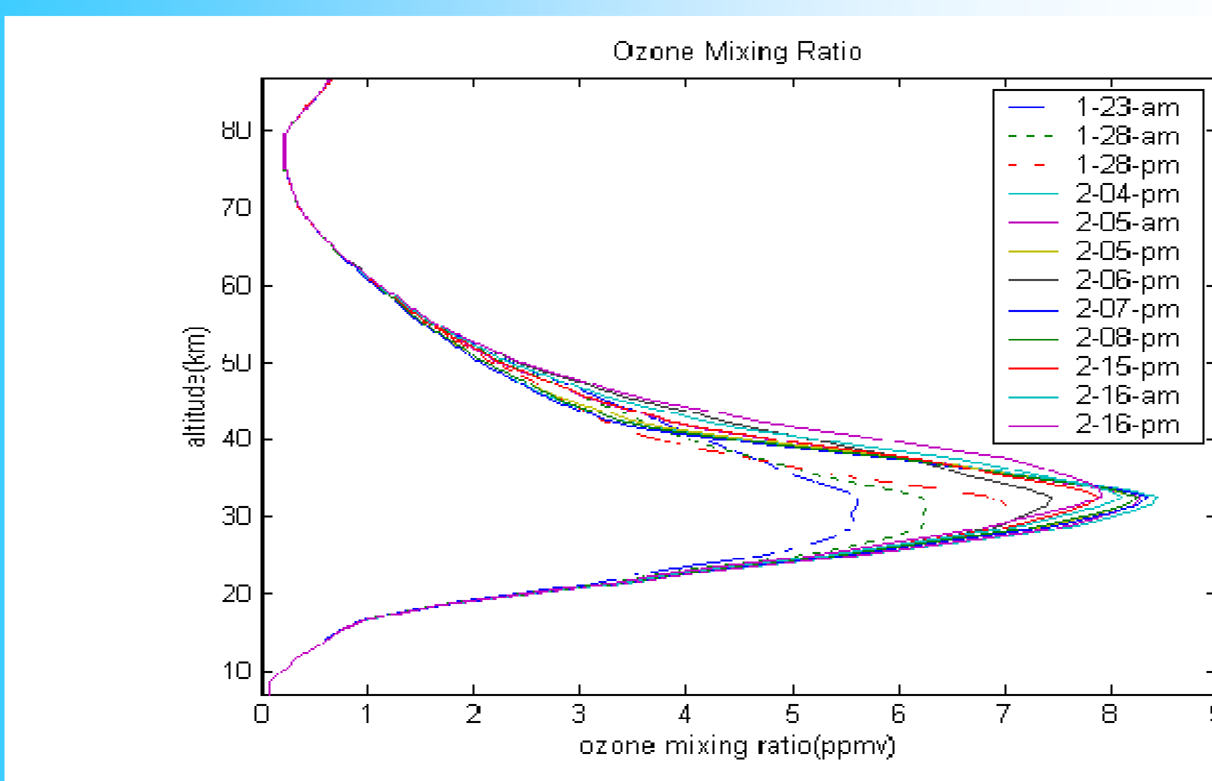


Ozone Mixing Ratio above Seoul

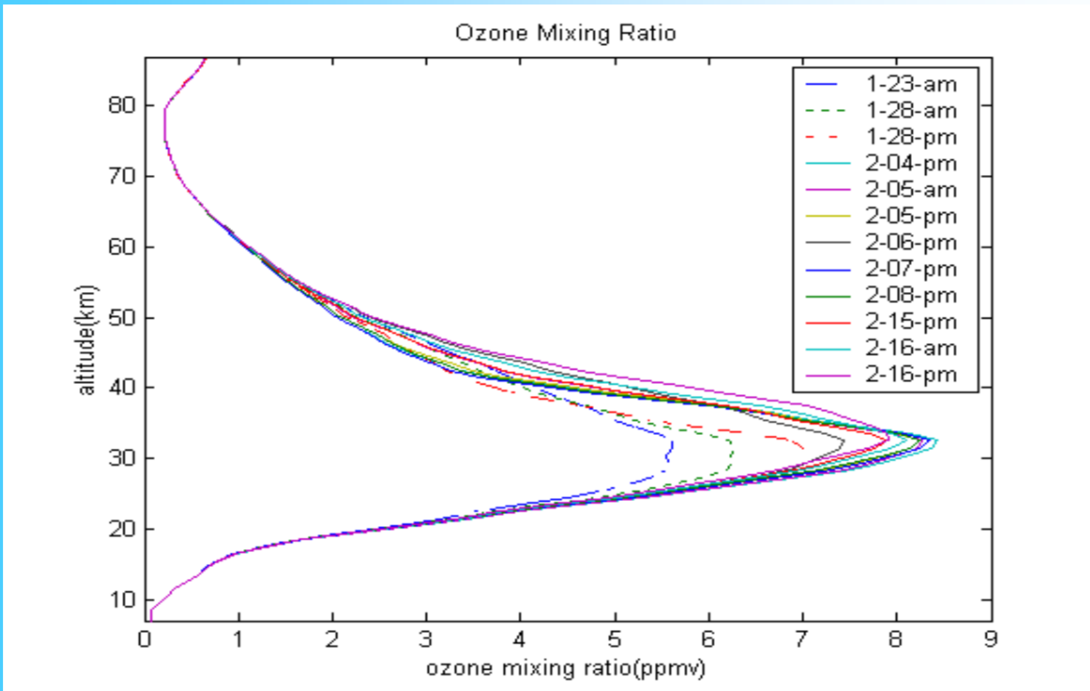


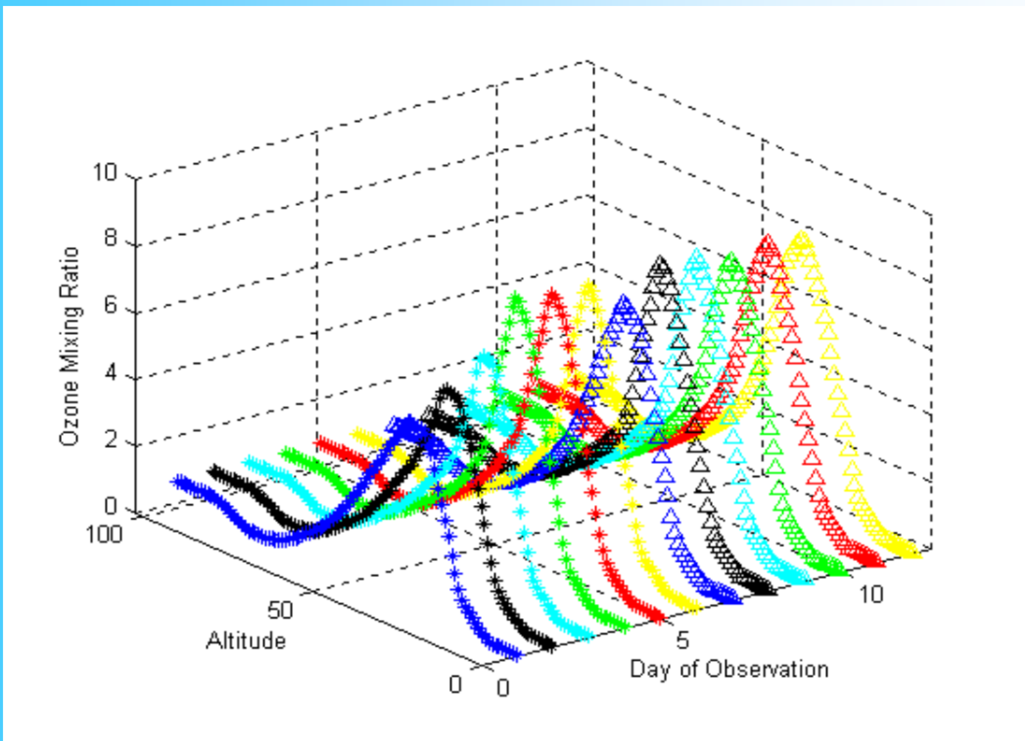
Vertical Profile of Ozone Mixing Ratio
(Comparison with HALOE Satellite Data)





Ozone Mixing Ratio above Seoul





Extra Consideration

1) Cosmic radiation

$$T_{B,strat} \rightarrow T_{B,strat} + T_{B,\cos mic}$$

$$T_{B,\cos mic} = 0.88K \quad (2.725K)$$

2) Window

$$T_{B,atm} = \chi_w T_{B,atm} + (1 - \chi_w) T_{B,window}$$

$$\chi_{window} = 0.99$$

3) Standing wave

- Rotating dielectric sheet (Rexolite)
- Phase length modulator

4) Offset and Slope

5) SSB Filter transmission

$$\chi_i = 0.5\{1 - \cos 2\pi \nu_i \frac{delta}{300}\}$$

$$delta = \frac{300(2n-1)}{2\nu_i}$$

$$= 1.3534(2n-1)mm$$

Conclusion

1. T_{sys} (system temperature) : about ~- 700 K

2. Measurement: Jan 22 - Feb 16, 2002.

3. Tropospheric attenuations are calibrated using Total Power Method (bias temperature).

4. Roger's Optimum Estimation method to retrieve the data has been used.

5. Error propagation analysis are under progress. (a priori profile and measurement error)

6. The altitude profiles of stratospheric ozone are compared with HALOE satellite data.

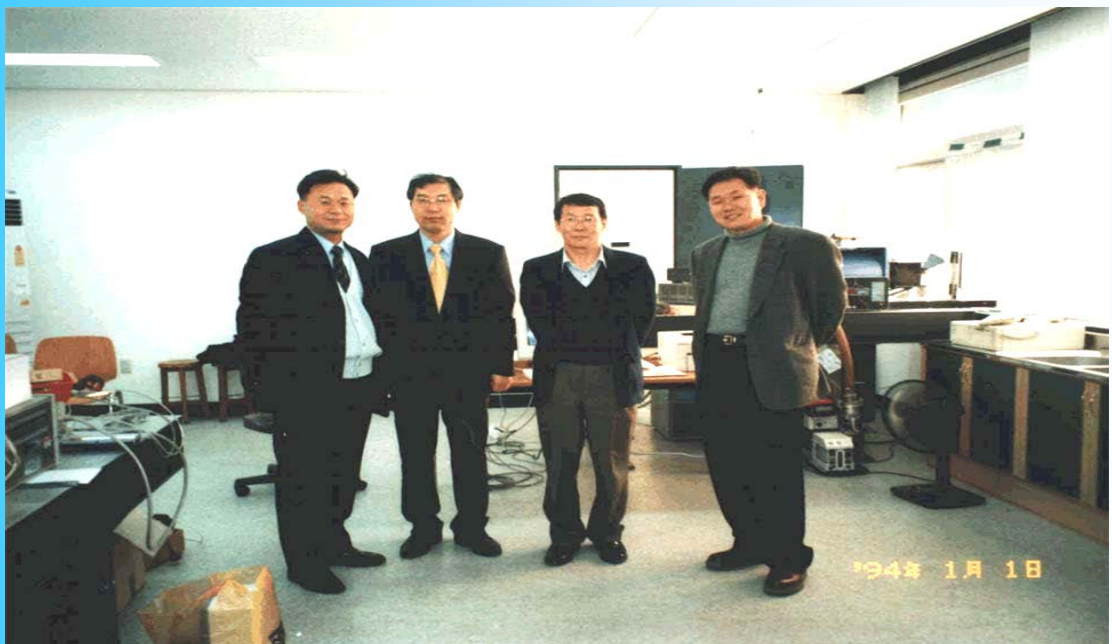
Concerns and Future Plan

- Baseline ripple
  - Cold load
- Power fluctuation, Spikes
  - Random (filter bank)
- Measurement time
  - Hot, Cold, Sky, Blank

$$\frac{\partial T_{atm}}{\partial P_{atm}} : \frac{\partial T_{atm}}{\partial P_{hot}} : \frac{\partial T_{atm}}{\partial P_{cold}} = P_{hot} - P_{cold} : P_{cold} - P_{atm} : P_{atm} - P_{hot}$$

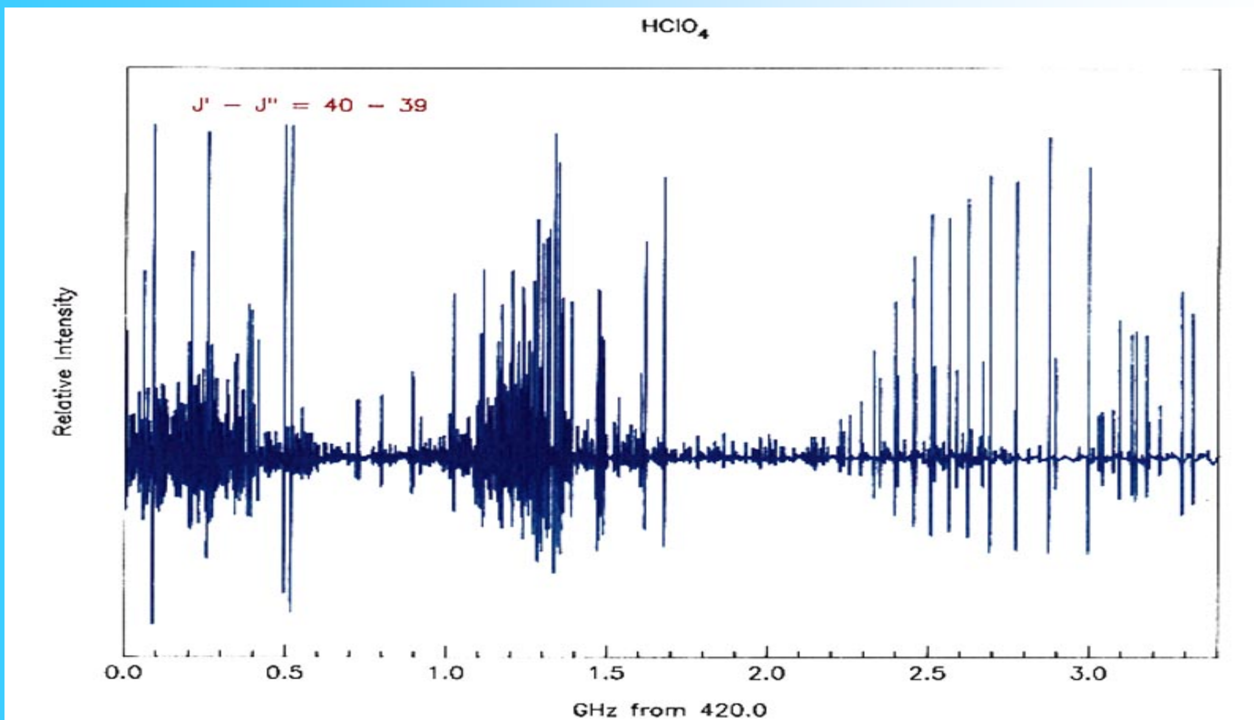
  - (Total Power Method, ex: 0.11, 0.7, 0.8 uW)
  - 16 (atm) : 1 (hot) : 9 (cold)
- New system
  - State of Art system configuration
  - Ozone (110, 142 GHz)
  - Mixer and Amp for water vapor (22 GHz)

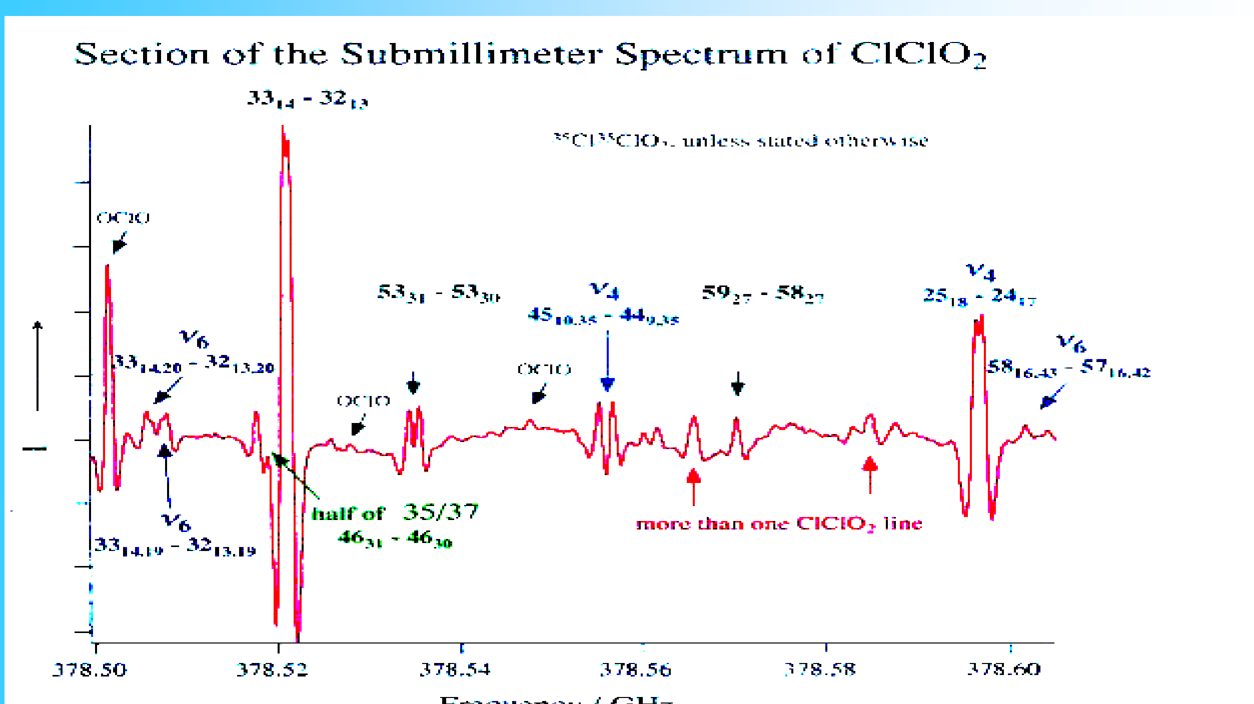
Acknowledgement



Microwave Spectrometer

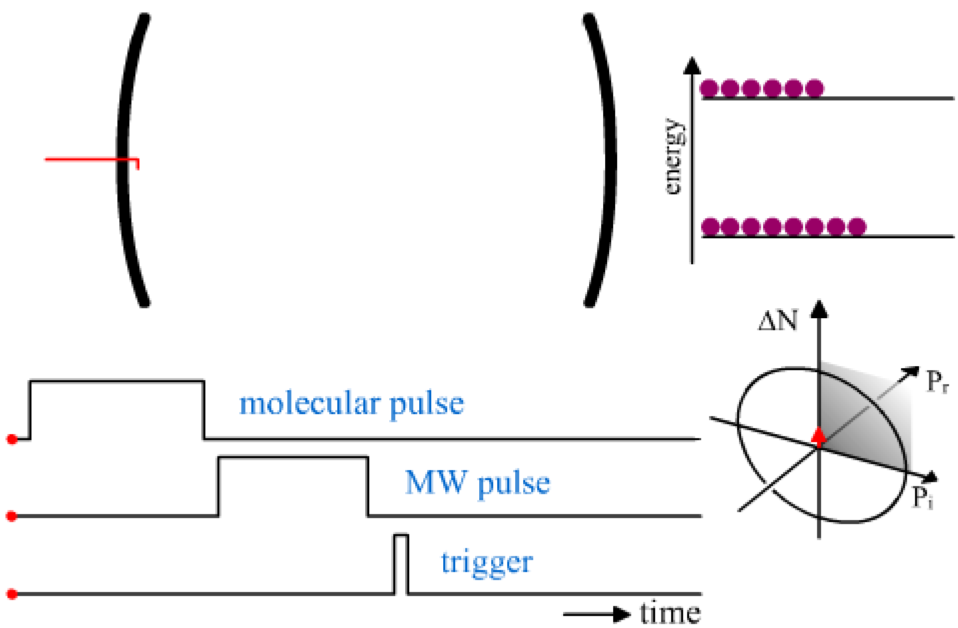
A portion of sample spectrum



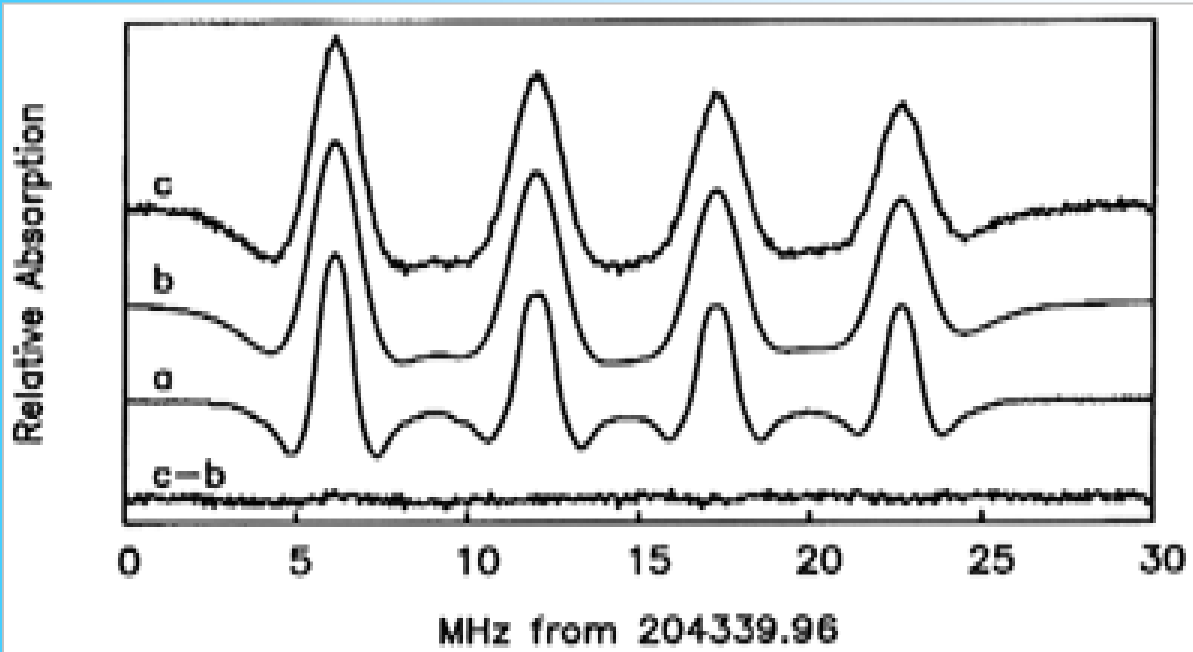


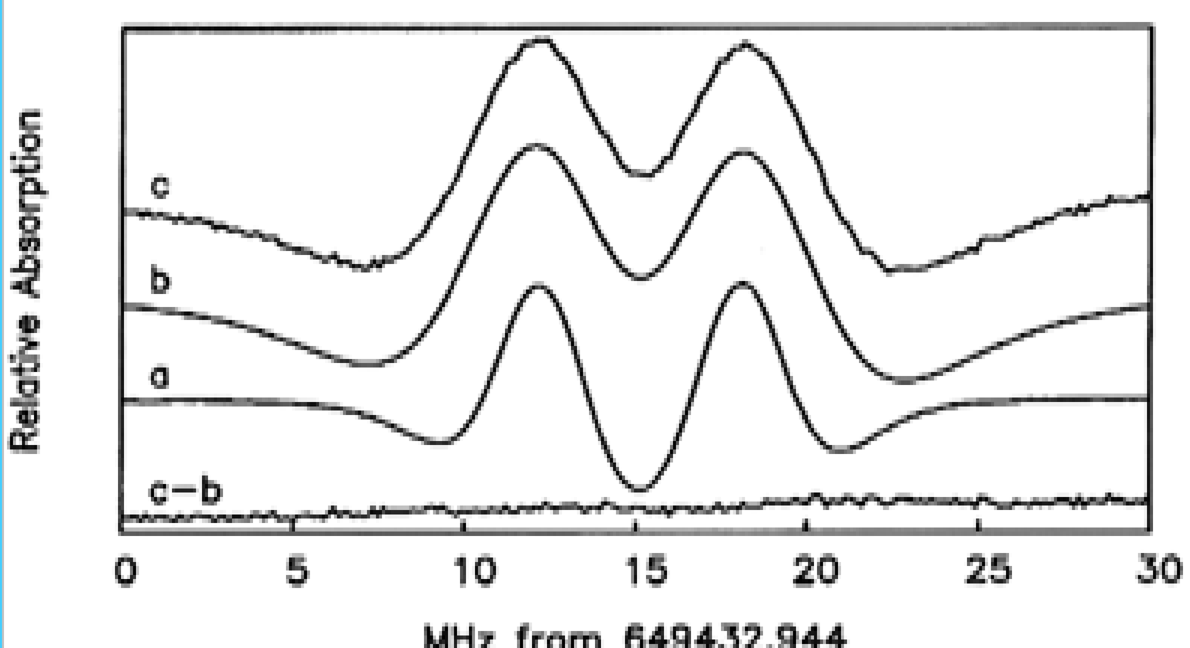
FTMW Spectrometer

How does a Fourier transform microwave experiment work?

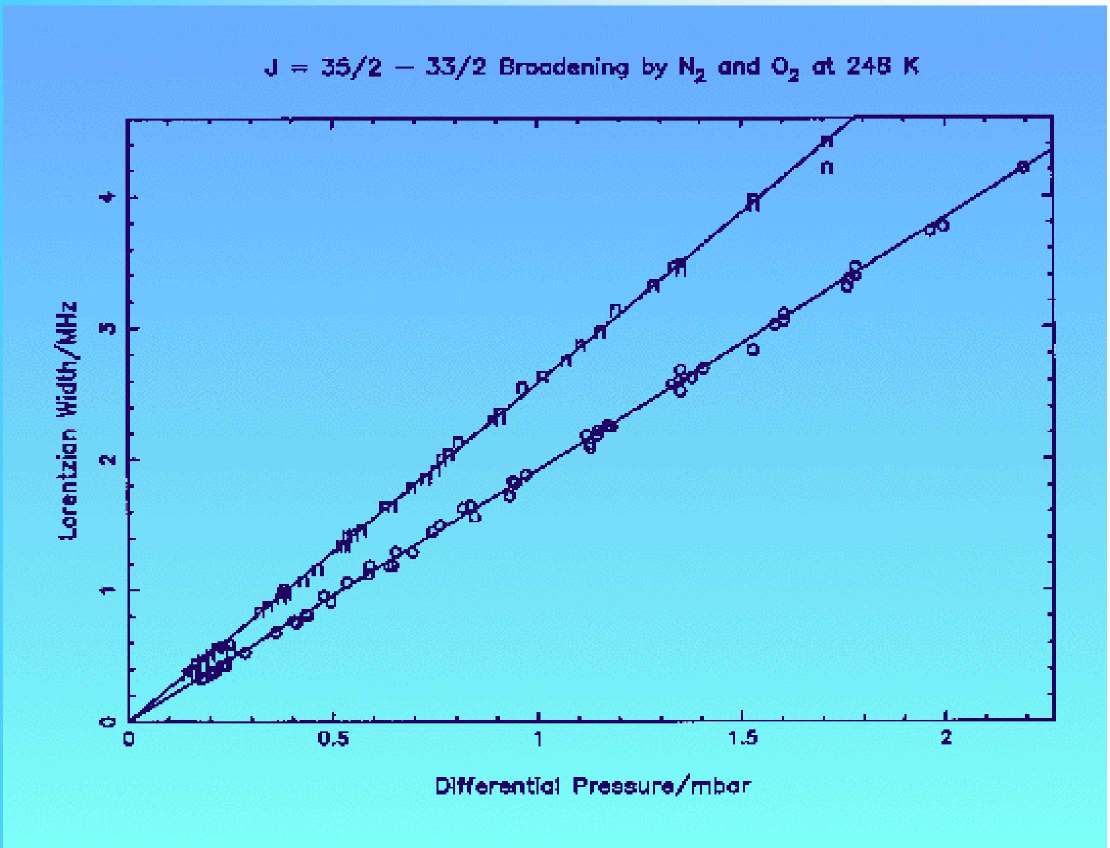


ClO의 pressure broadening





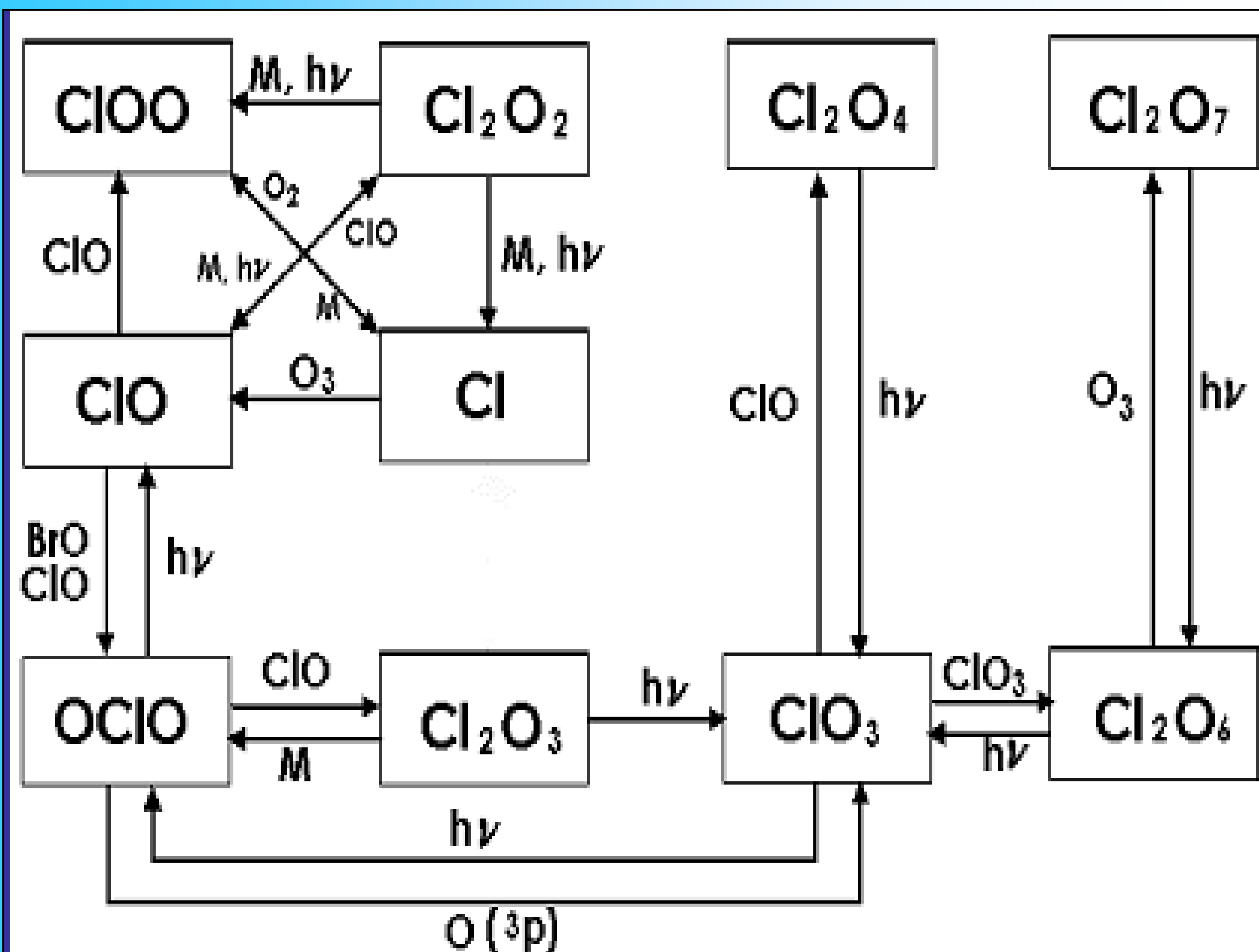
ClO의 pressure broadening



▶Lorentzian linewidth vs differential pressure of N_2 and O_2 broadening of ClO J = 35/2 - 33/2, at 248 K.

- A total pressure among ten spectra are plotted for N_2 and 58 differential pressures among eleven spectra for O_2. (J.J.Oh and E.A.Cohen, 1994)

Mechanism for Polar Stratospheric Chemistry of ClO_x



$$\frac{\partial T_{atm}}{\partial P_{atm}} : \frac{\partial T_{atm}}{\partial P_{hot}} : \frac{\partial T_{atm}}{\partial P_{cold}}$$

$$= P_{hot} - P_{cold} : P_{cold} - P_{atm} : P_{atm} - P_{hot}$$

→ measurement error를 줄이기 위한 관측시간
(for Total Power Method
(ex: 0.11, 0.7, 0.8)

$$\sigma \sim \frac{T_{B,sys}}{\sqrt{\Delta\nu\,\Delta t}}$$

$$\Delta T_A = \sqrt{\frac{1}{\Delta\nu_B}\left[\frac{(T_{sys}+T_C)^2}{\tau_C}\left(\frac{T_A}{T_H}-\frac{T_H}{T_C}\right)^2 + \frac{(T_{sys}+T_A)^2}{\tau_A} + \frac{(T_{sys}+T_H)^2}{\tau_H}\left(\frac{T_A}{T_H}-\frac{T_C}{T_C}\right)^2\right]}$$

$$\Delta T_A = \frac{T_A - T_{hot}}{T_{hot} - T_{cold}} \times \Delta T_{cold} + \frac{T_A - T_{cold}}{T_{hot} - T_{cold}} \times \Delta T_{hot}$$

$$\sigma = \frac{1}{\sqrt{N}}\frac{1}{\sqrt{2}}\left(\frac{1}{N-1}\sum_{k=1}^{N-1} y_{k+1} - y_k\right)^{\frac{1}{2}}$$

Atmospheric Measurement Frequency

	100 GHz	200 GHz	270 GHz	560 GHz	640 GHz
O_3	110.836	206.132	276.923	566.294	647.840
	142.175				
ClO		204.35	278.63	575.39	649.45
HOCl		202.485	270.832	555.697	648.618
BrO				576.31	627.36
HBr				500.647	
H_2O	183.310			556.936	
HO_2			265.770	569.390	625.660
H_2O_2		204.575	270.610	555.643	647.026
NO			250.437	551.188	651.433
NO_2			274.96	578.2	647.9
N_2O		200.975	276.328	577.575	627.748
HNO_3			269.210	544.350	647.759