The spectroscopic study of M8.5-M9.5 stars and brown dwarfs.

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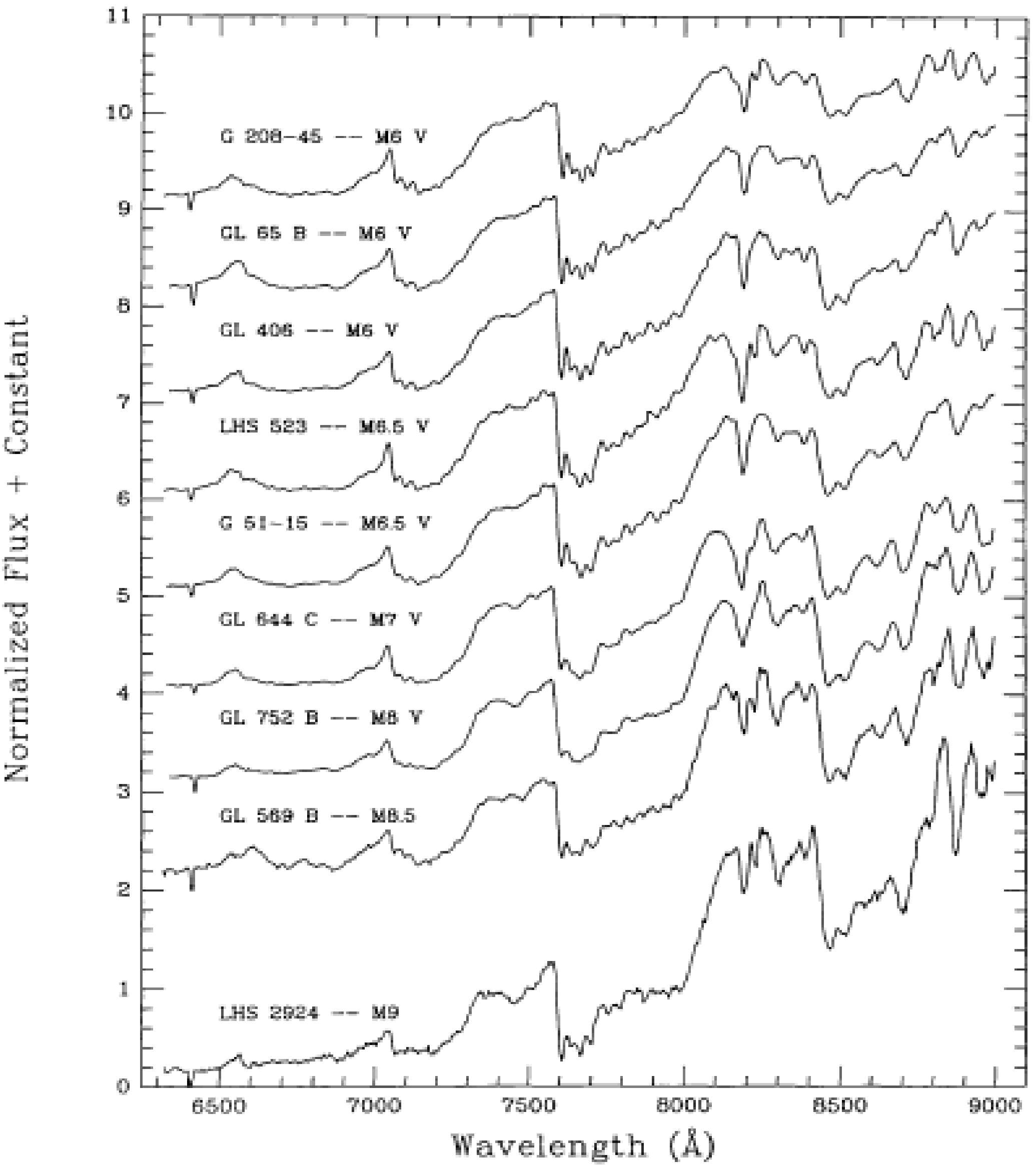
M dwarfs

- $0.1M_{sun}<M<0.8M_{sun}$ ~ 70% stars
- Late M could be brown dwarfs

- T_{eff} = 3500-2000 K
- Spectral sequence defined by development of molecular bands: TiO, VO, CaH and slope of red spectrum
- Few atomic lines (KI, NaI, RbI, LiI (for young stars and brown dwarfs)
- Convective atmospheres leads to high levels of magnetic activity, e.g flares, star spots
- increasing 'dusty effects', for late M decrease TiO,VO bands, scattering, T_{eff}, P in atm.



Kircpatrick (1991)

Our object sample

Objects from study of MG candidates. 3 late M dwarfs

Observations

UVES of VLT (ESO)
R~38000
Spectral range
blue: 5700-7530 A
red: 7650-9470 A

- **LP944-20** - archetypical brown dwarf

  SpT M9.0; 2040<T_{eff}<2400 K; [M/H]~0.0

  Basri (2000), Dahn (2002), Pavlenko (2007)

  bright, young (320-650 Myr), member of the Castor group Ribas (2003)

- **SIPS2045-6332** - brown dwarf (Li)

  SpT M8.5-M9.0; 2300<T_{eff}<2500 K; Reid (2007)

- **DENIS0021-4244** - brown dwarf

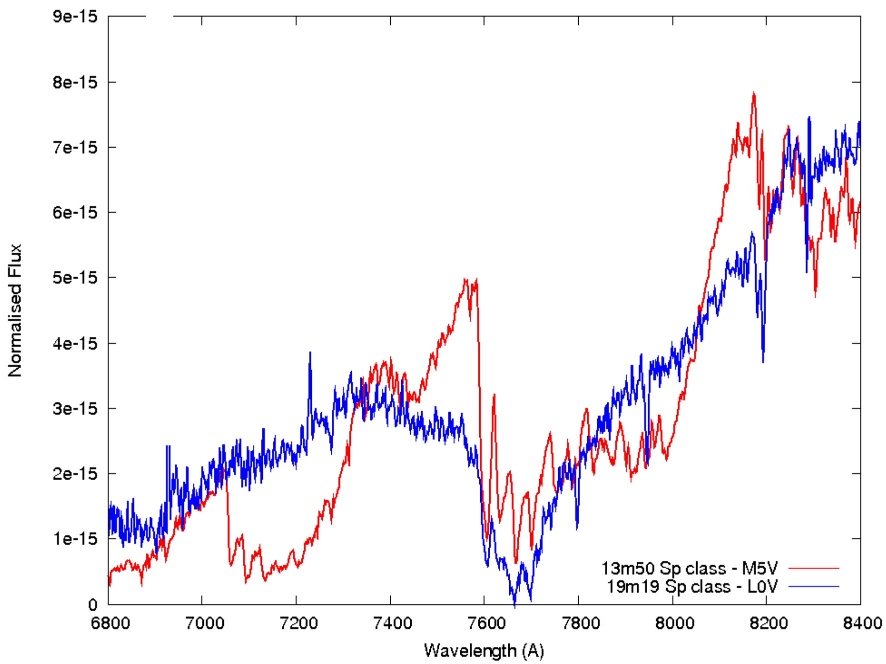
  SpT M9.5; 2300<T_{eff}<2500 K; Basri(2000)

  Wide ultracool binary M=0.079±0.004 $M_{\odot}$

  Caballero(2007)

Standard spectral modelling

DUSTY and **COND** model atmospheres (Allard 2001)

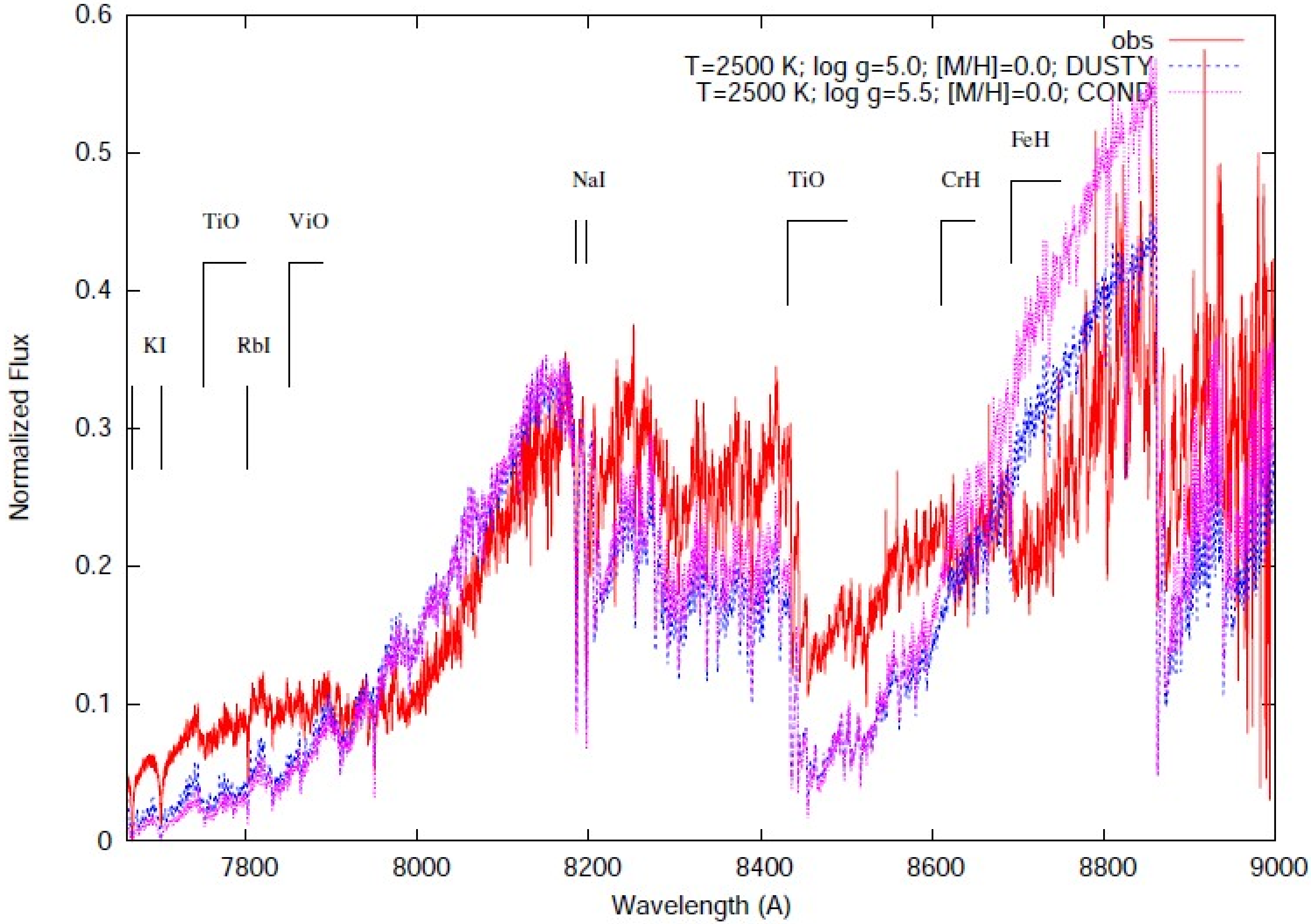


Synthetic spectra

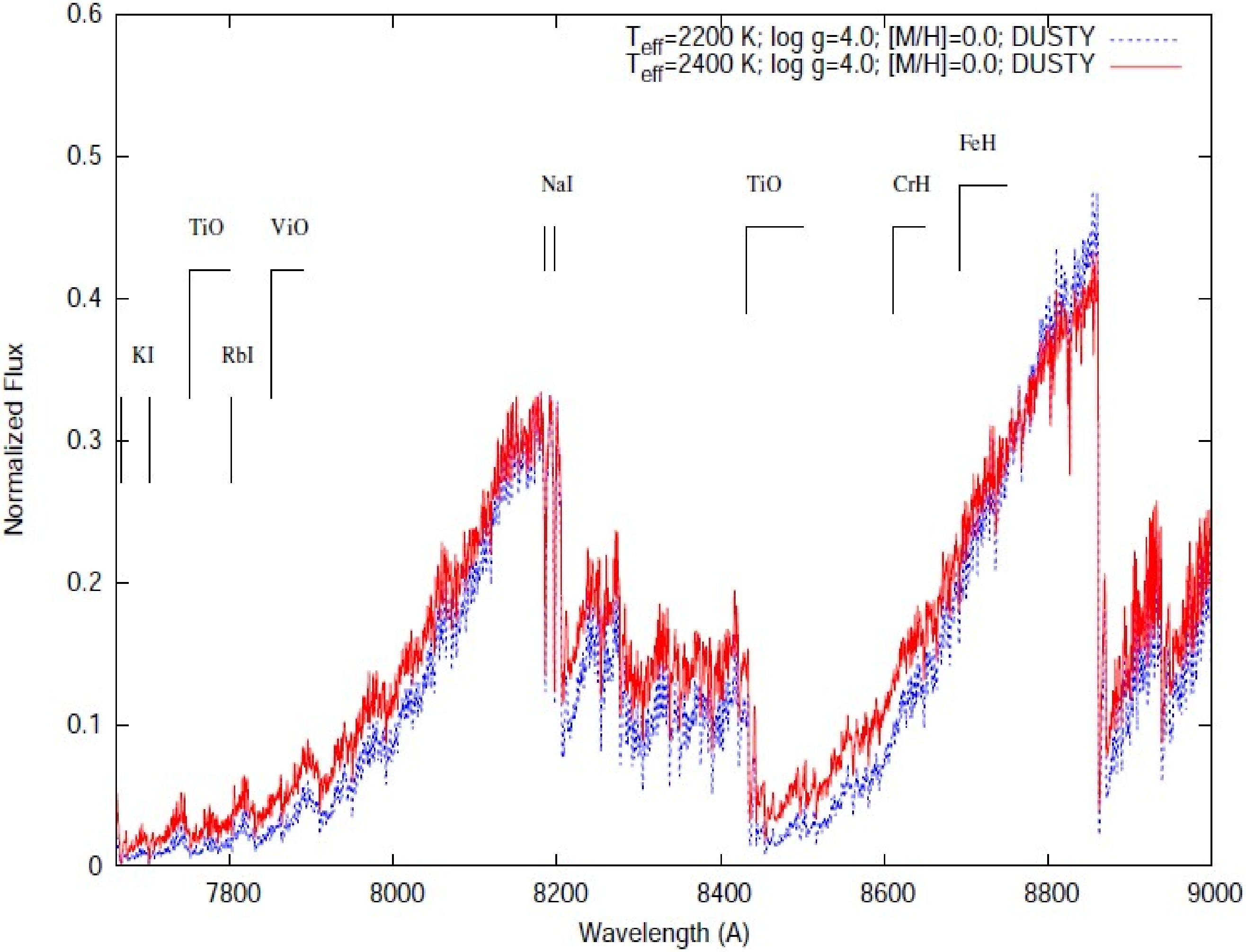
WITA5 (Pavlenko 2000)
Line lists: VALD (Kupka 1999)
TiO (Plez 1998)
JOLA for VO

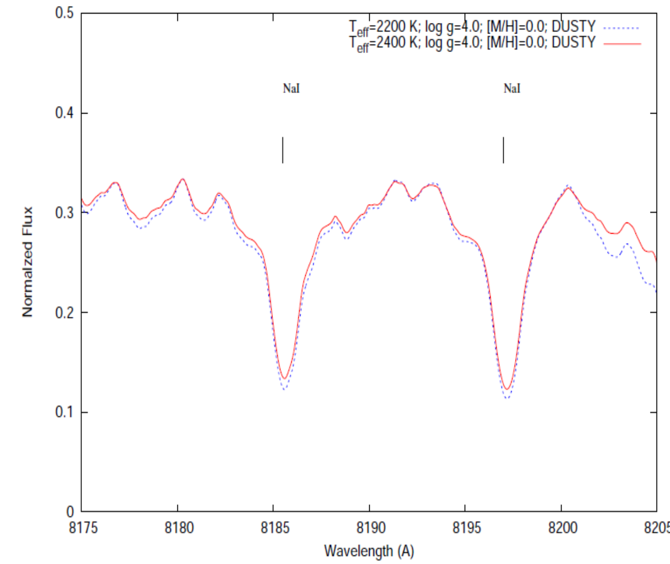
T_{eff}=2100-2500 K (step 100K); log g = 4.0-5.5 cm*s^{-2} (step 0.5);
[M/H]=0.0 dex; V_{sini} – from M.C. Galvez-Ortiz (2010)

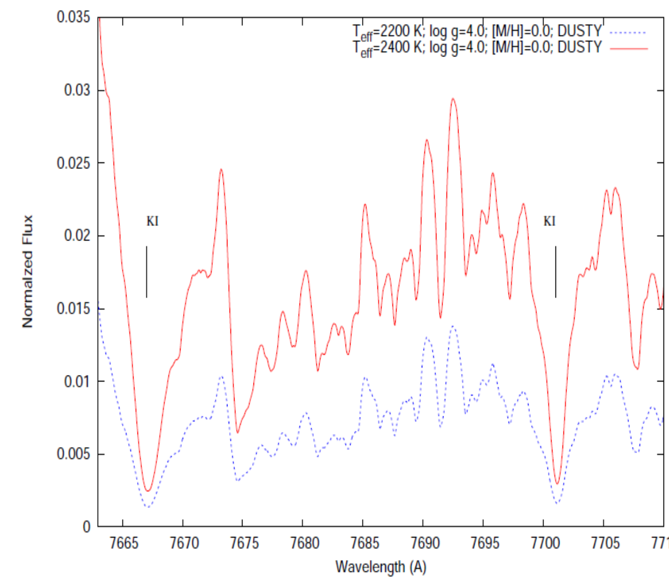
The best fit based on pure DUSTY and COND models



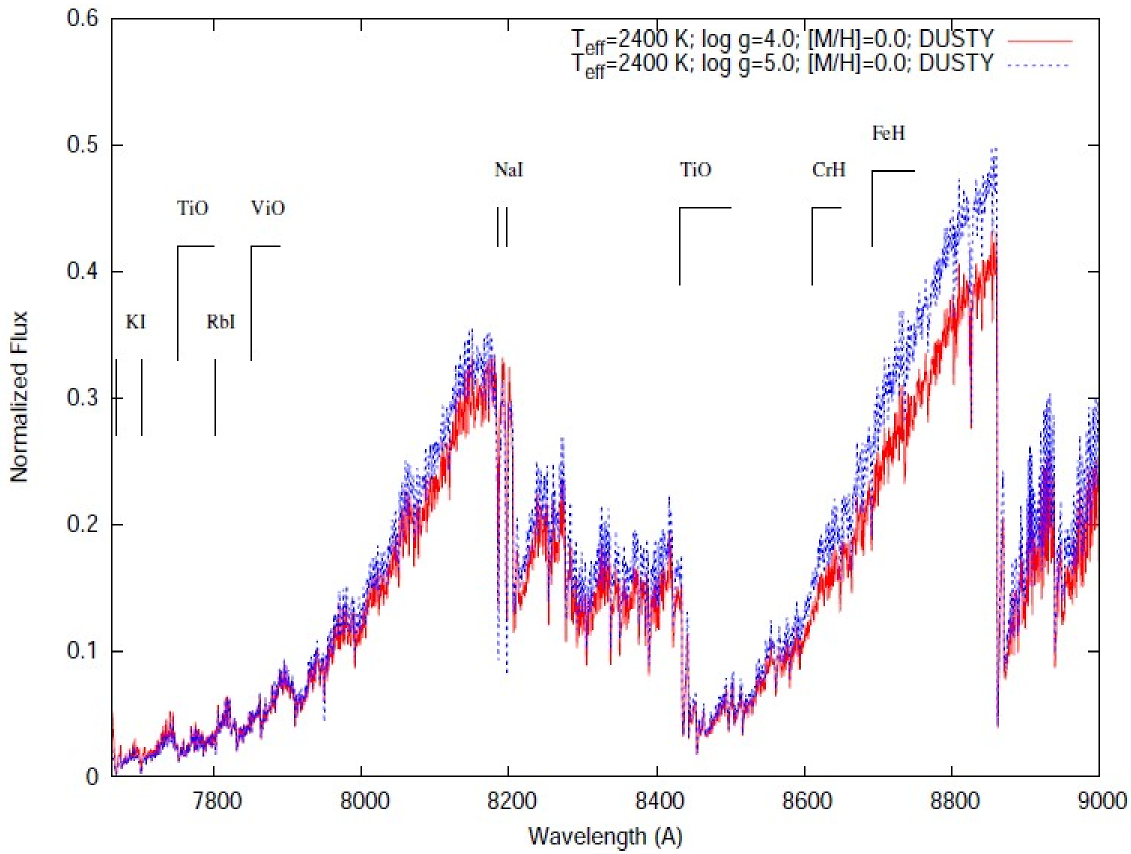
Sensitivity to the T_{eff}

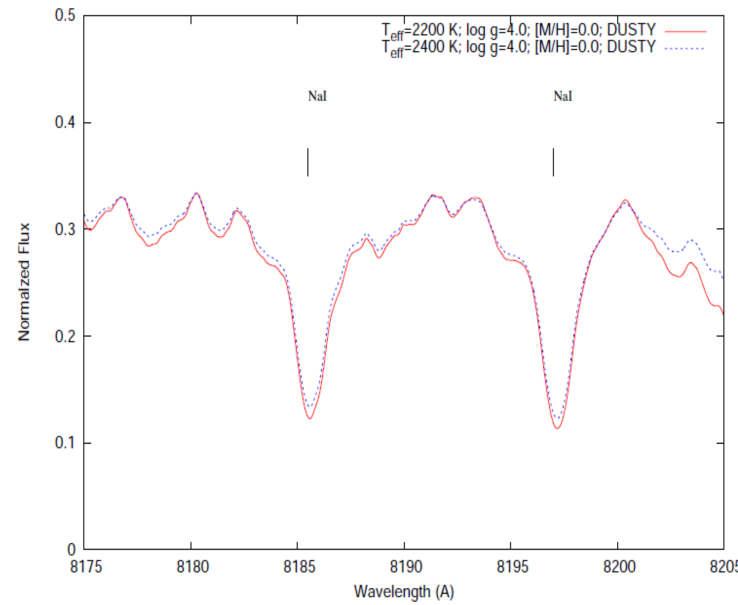


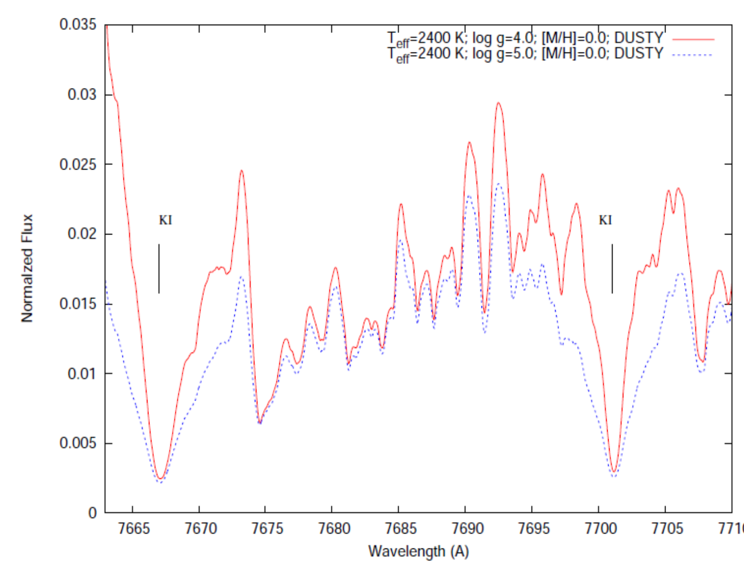




Sensitivity to the log g







Semi-empirical model of atmosphere

Semi-empirical model of atmosphere (Pavlenko et al. 2007) -
modified NextGen, DUSTY and COND models

Assumption:

dust clouds are located in the uppermost layers of stellar atmosphere and do not affect the distribution of temperatures and pressures

The influence of dust effects:

1. Decrease in the concentration of TiO,VO

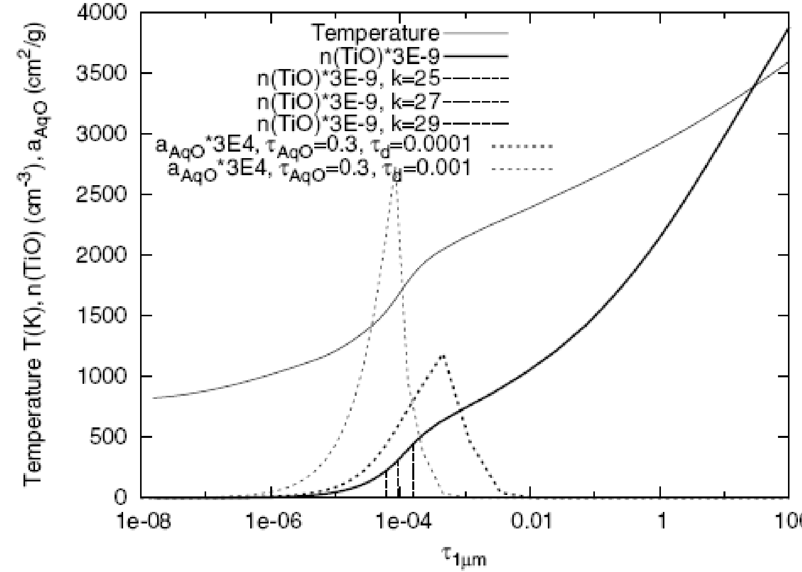
1.1 The number of the critical point in the model. There will be no absorption TiO,VO above this point (TiO,VO all fall to dust)

1.2 Coefficient of reduction of the concentration of TiO,VO

2. Radiation scattering in the dust clouds

2.1 The optical thickness of the dust cloud

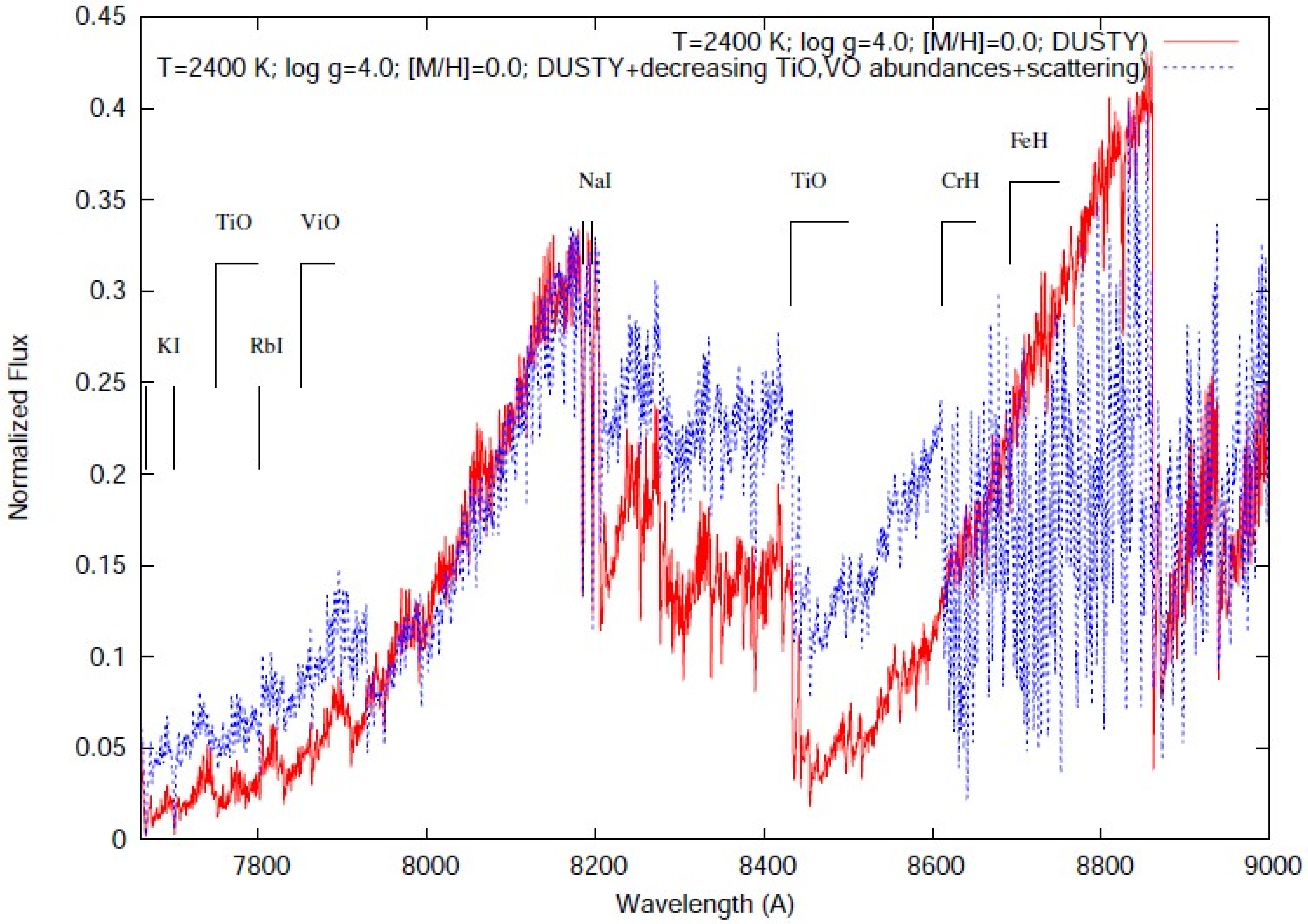
2.2 The depth of the clouds in the atmosphere



Structures of two SE model atmospheres from our grid.

Pavlenko et al. (2007)

Sensitivity to the additional "dusty effects"



KI and NaI lines broadening

$T_{eff} < 3000$ K

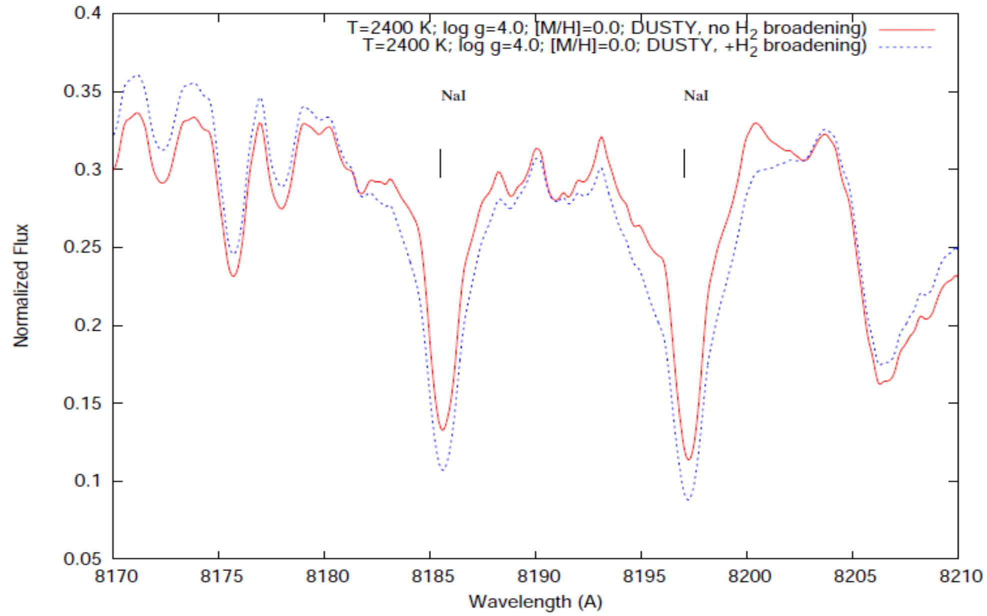
- natural and Stark broadening can be neglected
- broadening due to pressure plays a key role
- rich in H_2 - broadening of atomic lines by H_2

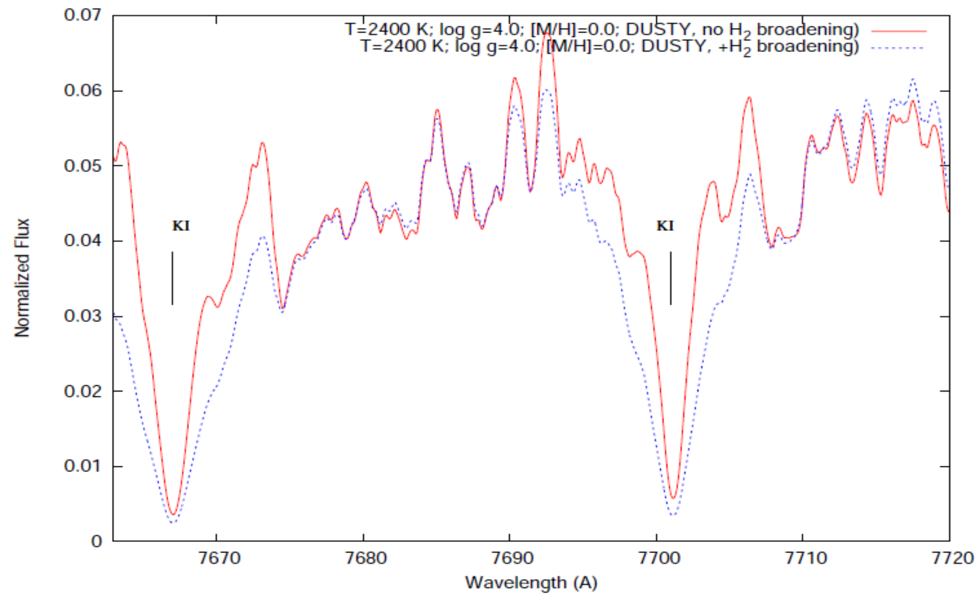
Broadening

van der Waals theory for early M dwarfs

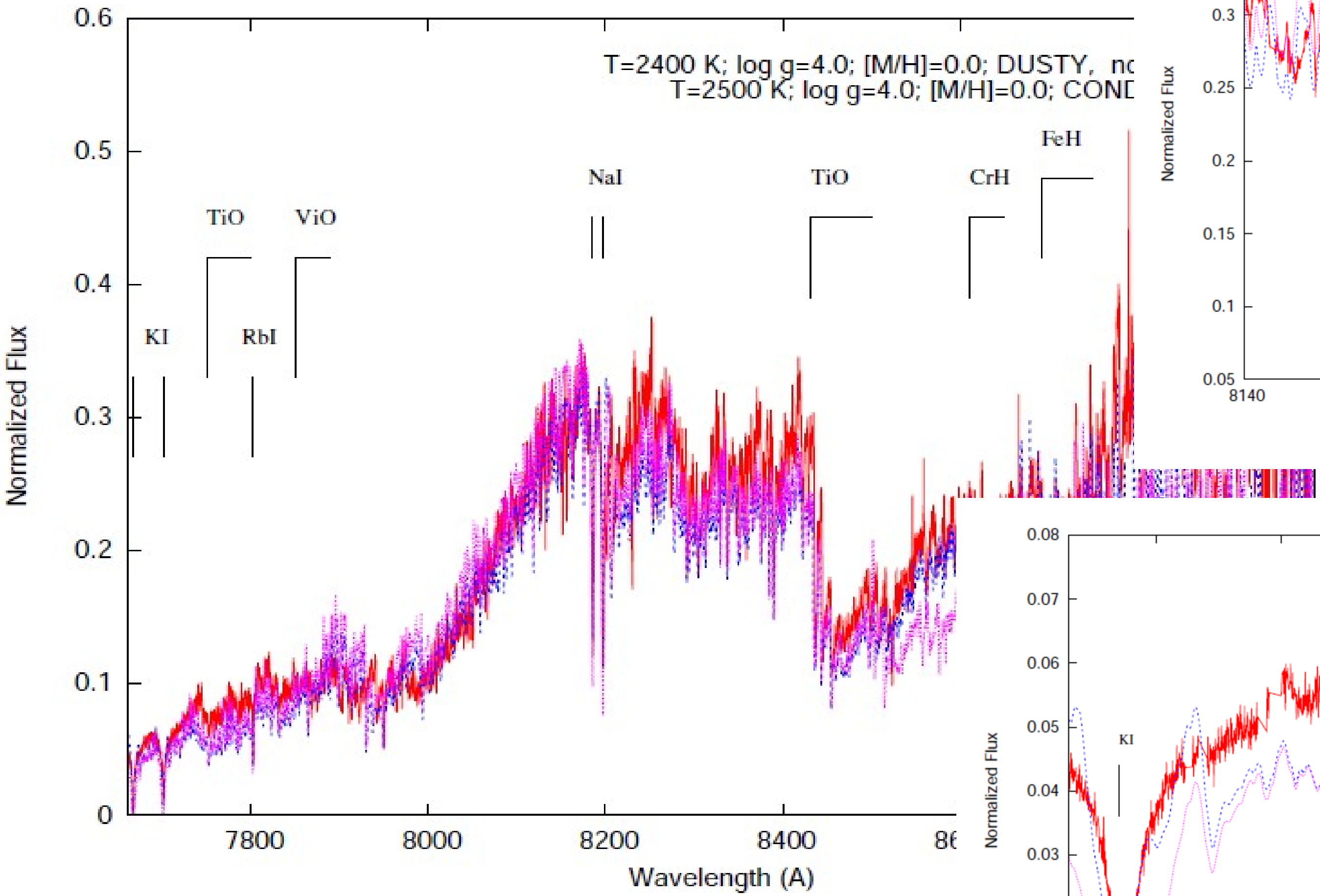
quasi-static theory for L dwarfs

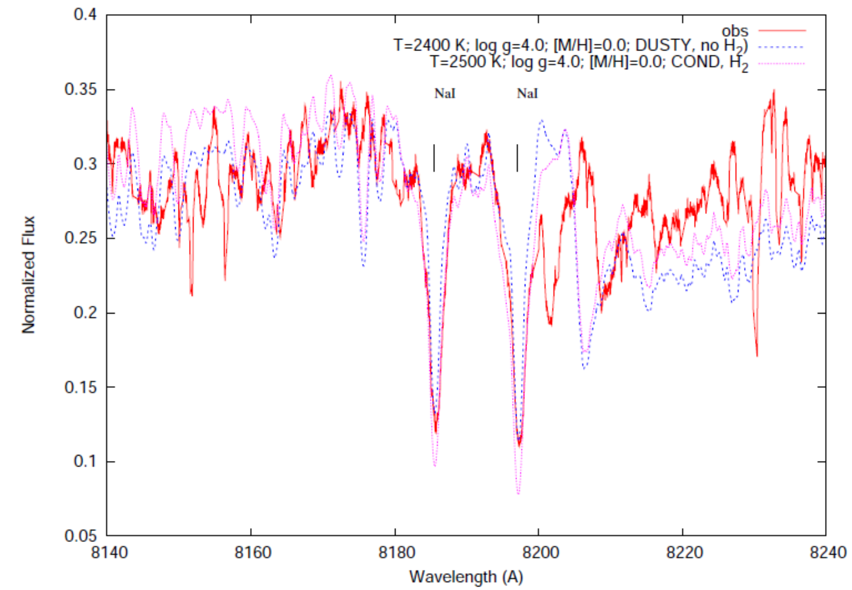
Synth. sp. - H_2 (van der Waals) and no H_2

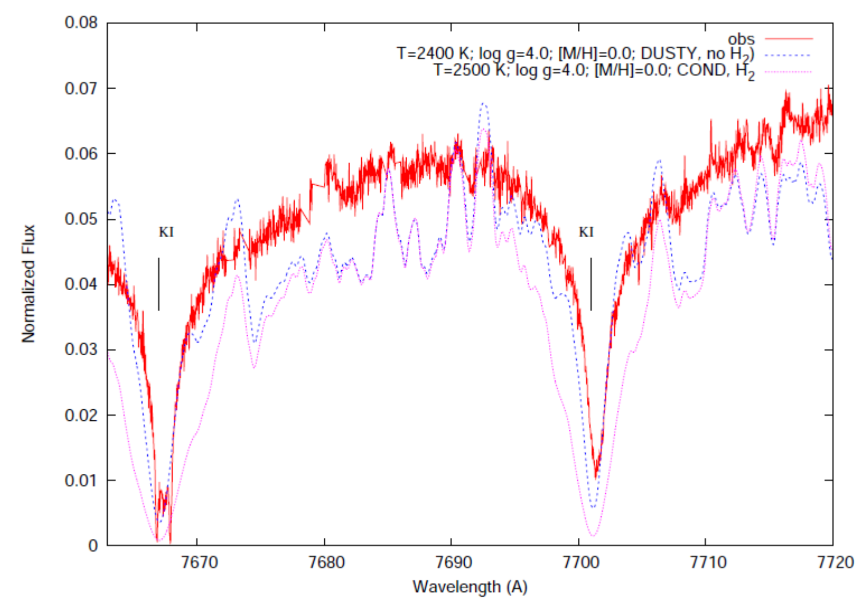




Best fitting



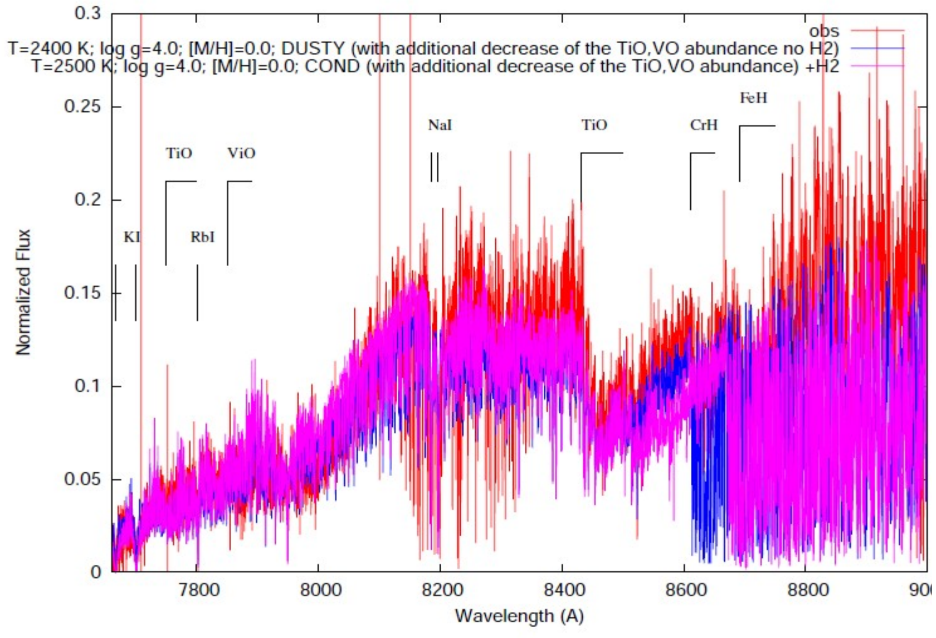




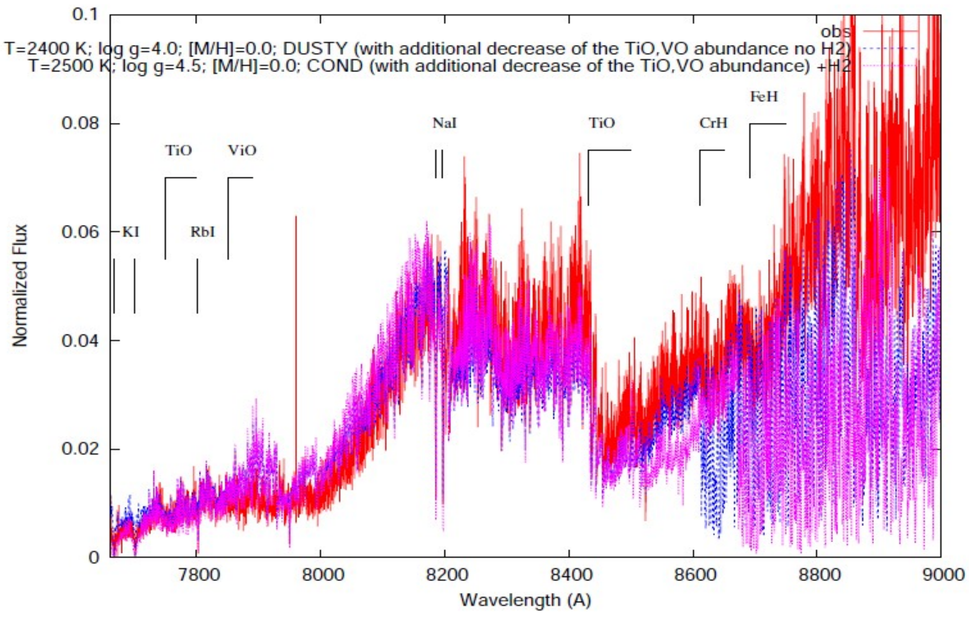
LP944-20

Results

		SpT	DUSTY				COND				
Object	*SpT*	$T_{eff}SpT$ (K)	T_{eff} (K)	*log g* (cm s^{-2})	[M/H] dex	S_{min}	T_{eff} (K)	*log g* cm s^{-2}	[M/H] dex	S_{min}	best fit
DENIS0021-4244	M9.5	2300-2500	2400	4.0	0.0	2.95	2500	4.0	0.0	3.03	DUSTY
SIPS2045-6332	M8.5	2300-2500	2400	4.0	0.0	10.00	2500	4.0	0.0	10.30	DUSTY
LP944-020	M9.0	2300-2500	2400	4.0	0.0	8.17	2500	4.0	0.0	8.81	DUSTY



SIPS2045-6332



DENIS0021-4244

Conclusions

- the additional "dusty effects" in DUSTY and COND models (Pavlenko 2007)
- Stellar parameters for 3 brown dwarfs SpT M8.5-M9.5

Acknowledgements

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Thank you