Galactic Structure and Stellar Populations Based on CFHT and LAMOST

Xiao, Quanbao
Shanghai Key Lab for Astrophysics
Shanghai Normal University
Together with
Shu,Chenggang;Shao, Zhengyi & Shen,Shiyin

Outline

- Motivation;
- The Milky Way model;
- CFHT stellar sample & model fitting;
- LAMOST data introduction;
- Project about the Milky Way structure and stellar populations with LAMOST data.

Motivation

- Today we know that four ‘components’ make for a sensible approximate description of the Milky Way stellar body.
- In many studies the range of values for the Milky Way model parameters is large.
- We expect to constrain the Milky Way model with deep CFHT and large volume LAMOST observations.

Galactic Model

- Disk-like populations
  - Thin disk
  - Thick disk
- Spheroid population
  - Stellar halo
- Bulge

Star counts technique

- Star counts:

$$A(m) = \int_r \varphi(M)\rho(r)r^2\omega\, dr$$

- Stellar density distribution.
- Assumption of luminosity function.
- Assumption of CMD.

- Spatial density distribution
  - Double exponential distribution for thin and thick disk

$$\rho_1(R,z) \propto \exp\left(-\frac{R-R_\odot}{L_1}\right)\exp\left(-\frac{|z-z_\odot|}{H_1}\right)$$

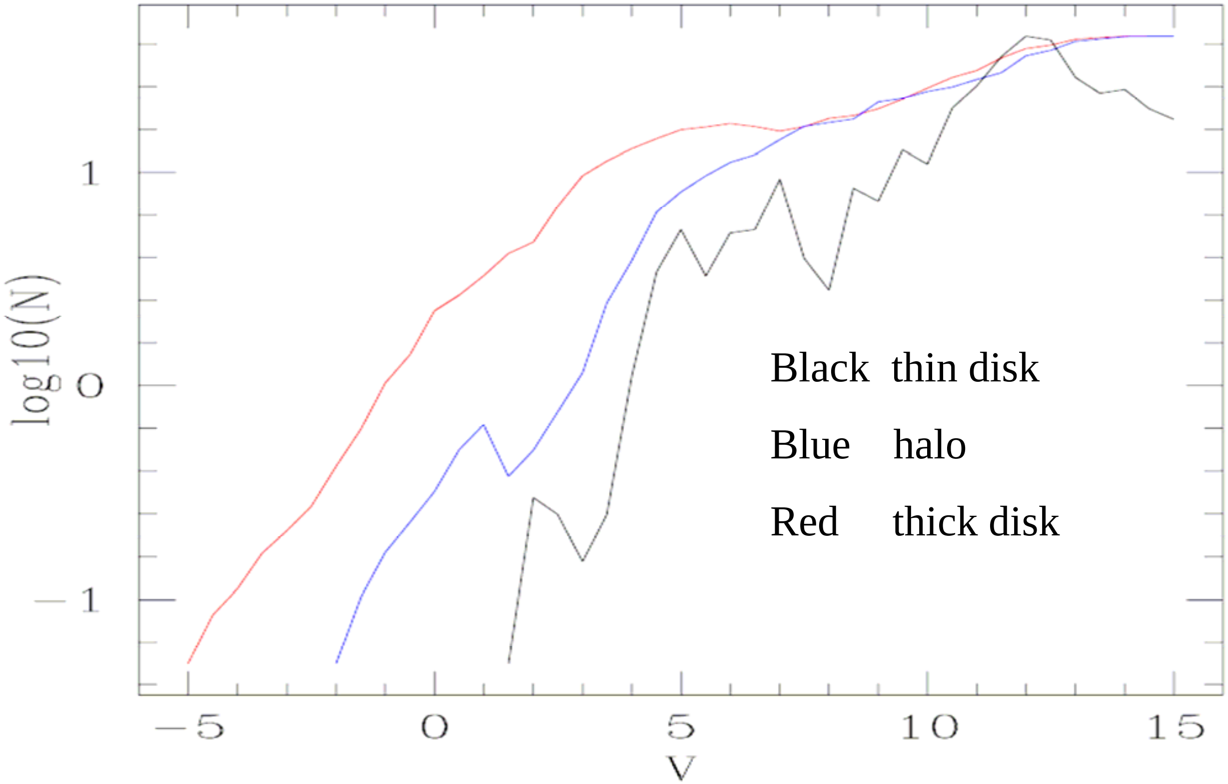
$$\rho_2(R,z) \propto \exp\left(-\frac{R-R_\odot}{L_2}\right)\exp\left(-\frac{|z-z_\odot|}{H_2}\right)$$

  - Power-law density for halo

$$\rho_3(r) \propto \left(\frac{r_c^2 + r^2}{r_c^2 + R_\odot^2}\right)^{n/2}$$

  - The galactic bulge is ignored.

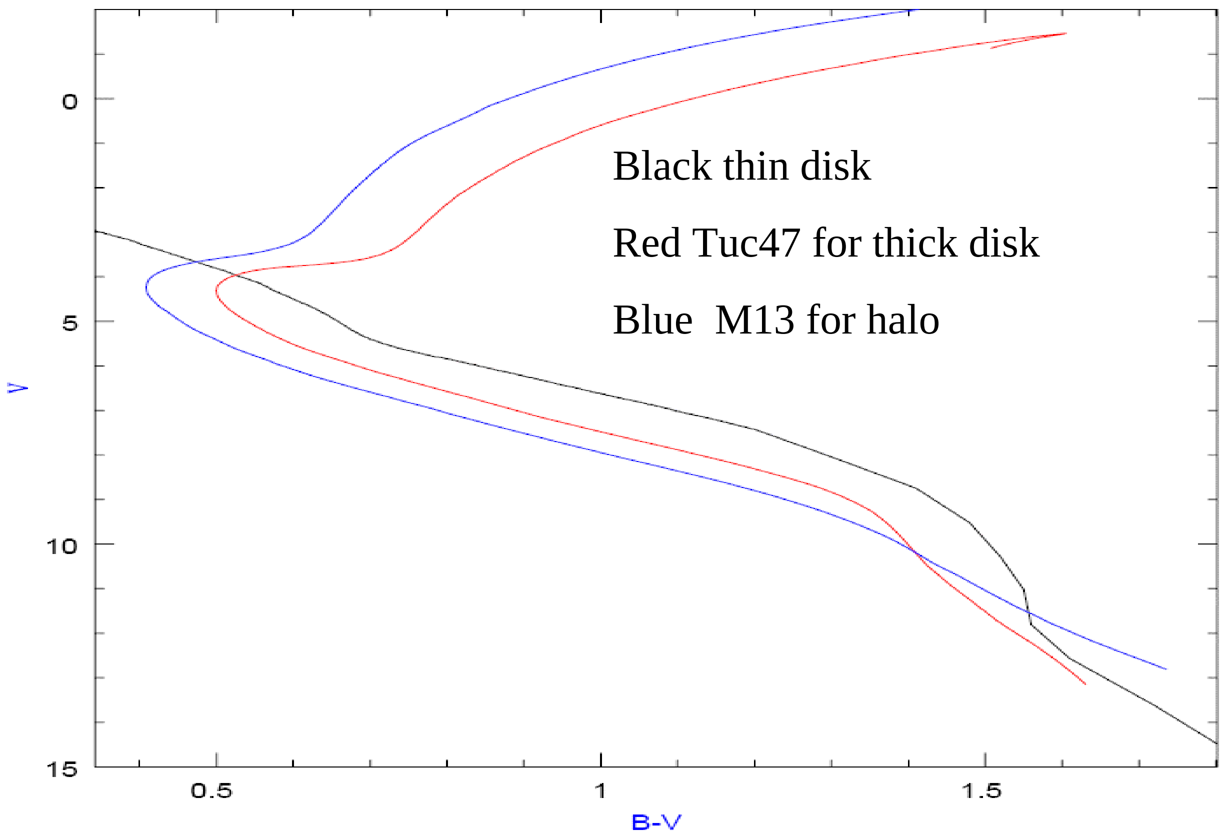
Assumptions of LF



The LF of thin-disk is nearby stellar one (Pavel Kroupa 1995) ;

The LFS of both halo and thick-disc are tabled in Robin et al.(1986)

Assumptions of CMD



The thin-disc CMD is constructed from main-sequence data given by Johnson (1965, 1966) and Keenan(1963); The CMD for halo is represented by the isochrone of M13,which predicted by DSEP code with [Fe/H]=-1.66 and [Alpha/Fe]=0.2; The isochrone of Tuc47, [Fe/H]=-0.76 and [Alpha/Fe] = 0.2, shows CMD for thick disk.

Stellar sample

- We construct the stellar sample based on the merged stellar catalogues of four wide fields of CFHT.
- Each field is observed in 5 filters(u,g,r,i,z) which is close to the filters of SDSS.

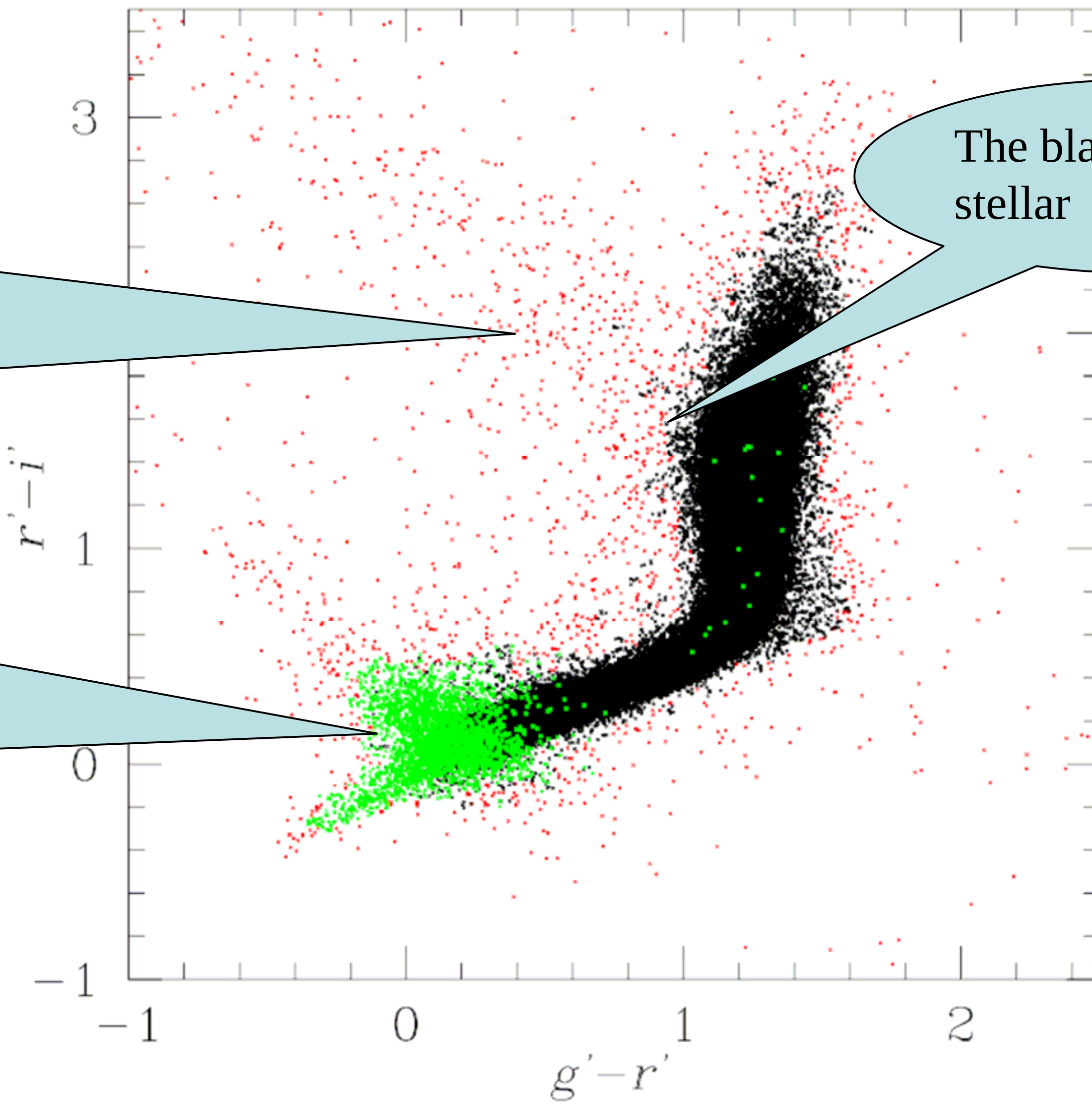
CFHTLS Field Name	α^{a} (deg)	δ^{a} (deg)	l^{b} (deg)	b^{b} (deg)
W1	34.5	−7.0	173.12	−61.59
W2	134.5	−3.3	231.78	26.04
W3	214.4	54.5	98.70	58.47
W4	333.3	1.3	63.32	−41.84

Field	All ugriz	Ns	$E(B-V)_{median}$
W1	49	88123	0.025
W2	25	134755	0.019
W3	30	59706	0.010
W4	20	91772	0.056

上海师范大学
Shanghai Normal University since 1954

SHANGHAI Key Lab for Astrophysics

17.5 mag < i < 21.0mag



The red dots are excluded because of be far away from the main locus of the double colors.

The black dots: stellar candidates

The green dots (u-g < 0.8): contaminations of nearby quasars

Method

- Generating a grid of star catalogues for each population in given wide fields by Montle carlo method.

thin disk	thick disk	halo	sun
kpc	kpc		kpc
$L_1 = 2.25$	$L_2 = 3.5$	$c/a = 0.4 \sim 1.0$ $step = 0.02$	$R_\odot = 8.0$
$H_1 = 0.1 \sim 0.4$ $step = 0.006$	$H_2 = 0.5 \sim 1.5$ $step = 0.02$	$n = 2.0 \sim 3.8$ $step = 0.06$	$z_\odot = 0.027$

- The determination of the best-model is divided into two steps:
  - First step: fitting the redder stars (g-r > 1.0) , which is dominated by the disk populations, and determine the parameters of thin disk and thick disk.
  - Sencond step: fitting all stars with determined disk parameters to get the best-model of stellar halo.
- The best-fitting models are achieved by a maximum likelihood method (Bienaymé, Robin, & Crézé **1987**)

Best-fitting Models

field	H_1	H_2	ρ_2/ρ_1	ML_1	n	c/a	ρ_3/ρ_1	ML_2
W1	0.214	0.70	10.7%	-8.17	2.90	1.0	0.080%	-509.31
W2	0.220	0.58	7.9%	-2.02	3.62	0.82	0.315%	-544.89
W3	0.214	0.66	11.9%	-4.00	2.84	1.0	0.043%	-228.57
W4	0.226	0.68	10.4%	-8.31	3.50	0.92	0.069%	-328.31

- Thin disk: H1~220pc
- Thick disk: H2~700pc except for W2
- Thick-to-thin disk density normalization is around 11% except for W2

- **Given the binary fraction 35% (Reid & Gizis 1997), H_1 and H_2 are underestimated by 15%, and the thick disk density is overestimated by 10% (Juric et al. 2008).**
- **Correction for binaries**
  - the derived H_1 ~ 260 pc is near the lower end of the range (240-350 pc) (Robin et al.1996; Buser et al. 1999, Chen et al.2001);
  - H_2=680-820pc is closer to the higher end of 580 - 790 pc (Robin et al. 1996; Ojha et al. 1999; Chen et al. 2001);
  - Local thick disk normalization,7% - 11%, is in agreement with the recent determination by chen et al.(2001)(6.5%-13%), Siegel et al.(2002) (>10%) and Juric et al. (2008) (~12%)
- **Our results and recent results disfavor the thick-disk model with the parameters characteristic of early 'low-normalization/high-thick scale height'(Gilmore & Reid 1983;Robin & Creze 1986; Reid & Majewski 1993)**

- **The fits of halo model are significantly poorer than for the disks. The best-fitting models show that the stellar halo is sharp(n>2.8) and round(c/a > 0.8).**
- **It is difficult to constrain the stellar halo because the presence of clumpiness and merger debris in the halo.**
- **Instead of a single power law, a two-component 'dual halo' may be invoked to explain the observations (Sommer-Larsen & Zhen 1990)**
  - The flattened subcomponent is a result of the initial monolithic collapse
  - The spherical component originate from subsequent accretion of satellites

Summary

- The galactic disk-like populations can be constrained by CFHT observations. The corrected scale heights are in good agreement with recent literatures.

- It's difficult to constrain the model of stellar halo. A dual halo model maybe explain the observations.

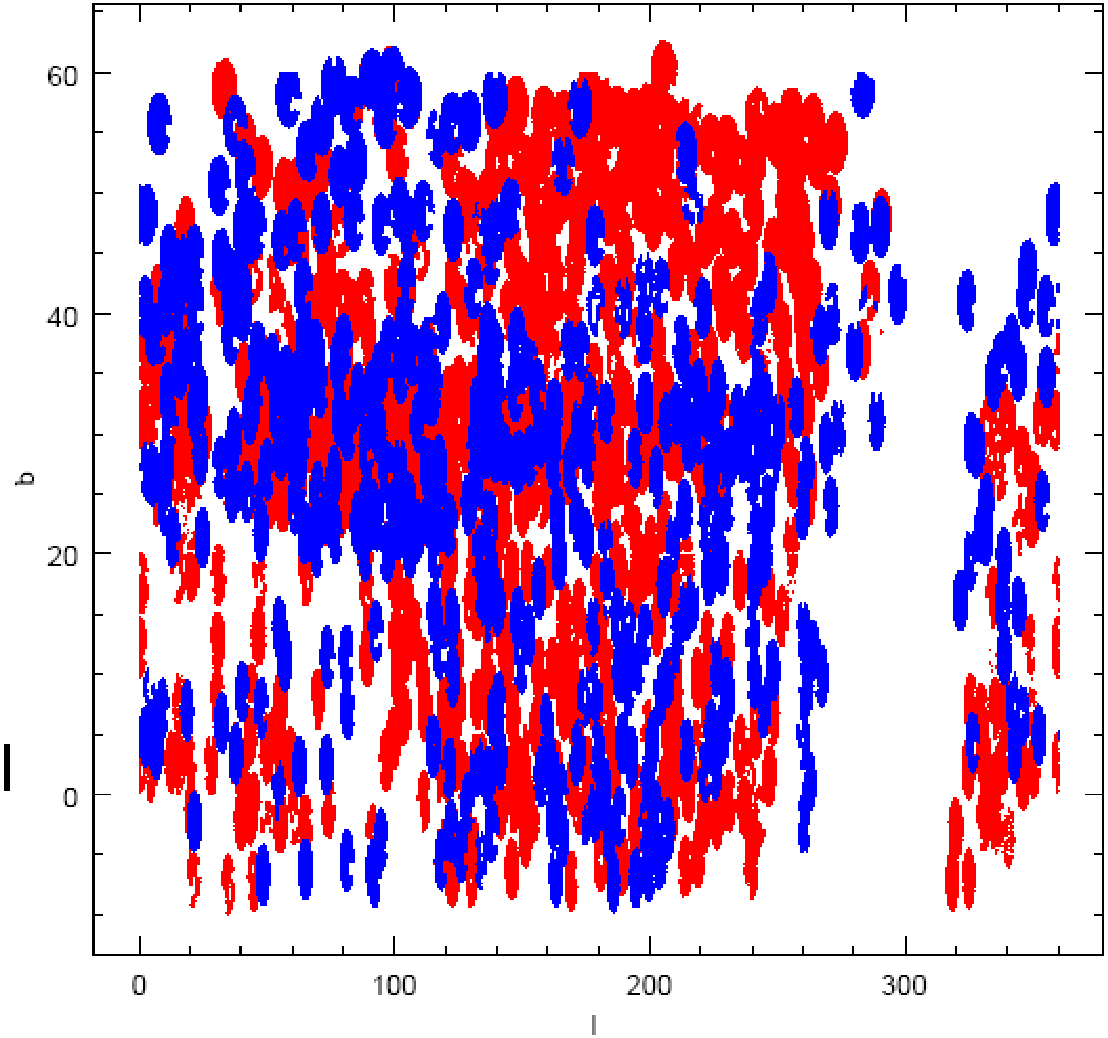
LAMOST

The largest stellar spectral parameters catalog

Radial velocity

Stellar type

Stellar physical parameters

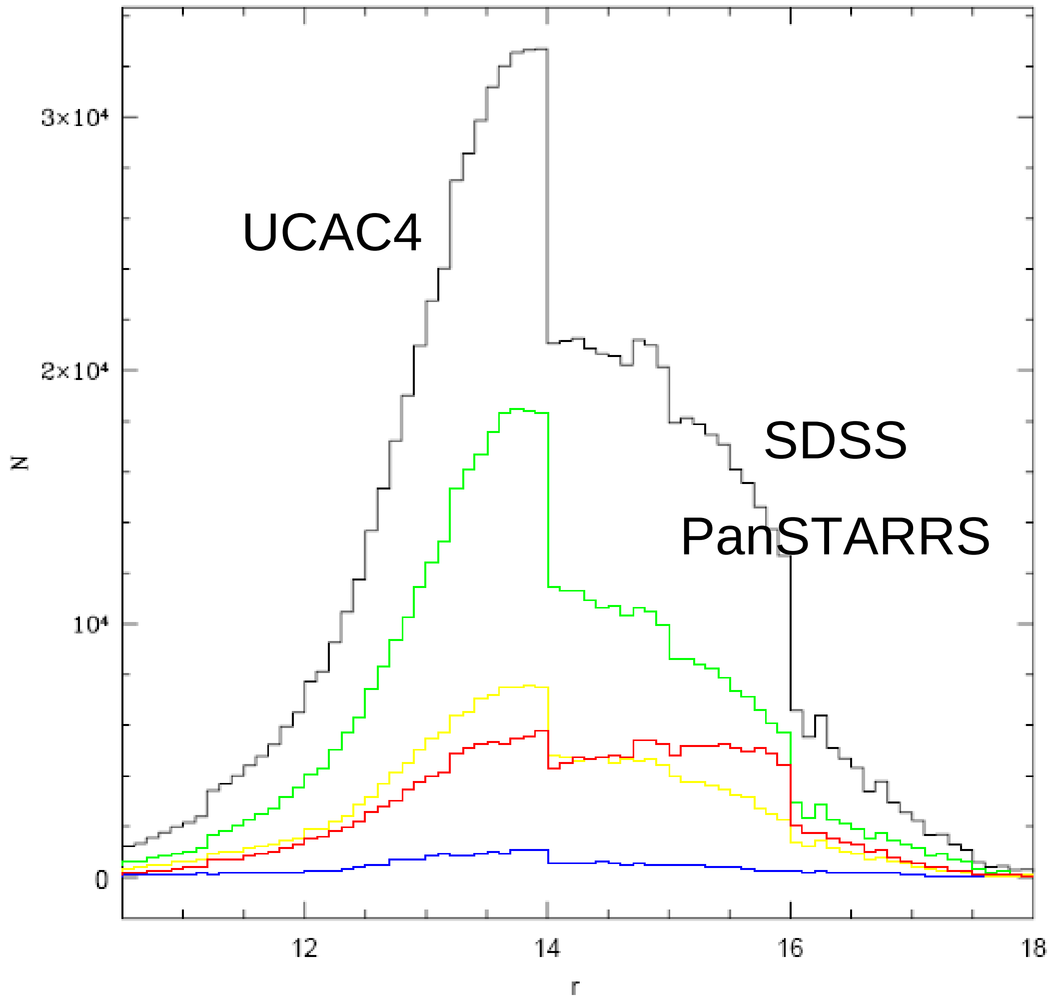


Stars in LAMOST

- Overview of stars:

	N_{all}	N_{star}	N_A	N_F	N_G	N_K	N_M
DR1	2204696	1867074	97038	788949	401280	455432	118882
DR2	1427923	1203416	56150	310672	533125	236360	64016

Stellar sample



Completeness

- Select effect:

  a. input catalogues

  b. assignment of fibers

  c. specific observation condition

- Estimation of completeness:

  a. comparing with the simulation of Galactic model

  b. comparing with other observations(SDSS..)

Estimation of stellar distance

- For Giant stars, using synthetic isochrones with calibration based on globular clusters(~$3*10^5$ Giants , Liu et al. 2014).
- For main-sequence stars,using stellar spectral type,metallicity and synthetic isochrones to estimate distance.

The milky way global structure

- Using star counts technique to study the global stellar distribution;

  Giants for stellar halo;

  Giants+main sequence for stellar disks.

- Trying to constrain the Milky Way model with star counts and dynamic radial velocity simultaneously.

Specific-type stars distribution in the Milky Way

- To investigate the geometric, dynamic and metallicity distributions of the specific type stars
- To compare the distributions of different type stars to explore the formation and evolution of the Milky Way.

上海师范大学

Shanghai Normal University since 1954

SHANGHAI Key Lab for Astrophysics

Thanks !