Background Quasars in the Vicinity of M31 and M33 with LAMOST

Zhi-Ying Huo[1], Xiao-Wei Liu[2], Mao-Sheng[2], Jian-Rong Shi[1], Hai-Bo Yuan[3], Yang Huang[2], Yong Zhang[4], Yong-Hui Hou[4], Yue-Fei Wang[4] and Ming Yang[1]

1. National Astronomical Observatories, Chinese Academy of Sciences, Beijing, 100012, China
2. Department of Astronomy, Peking University, Beijing, 100871, China
3. Kavli Institude of Astronomy and Astrophysics, Peking University, Beijing, 100871, China
4. Nanjing Institude of Astronomical Optics & Technology, Chinese Academy of Sciences, Nanjing, 210042, China

Abstract In this work, we report new quasars discovered in fields in the vicinity of the Andromeda (M31) and Triangulum (M33) galaxies with the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST, also called the Guo Shou Jing Telescope), which represent a significant increase in the number of identified quasars in fields in the vicinity of M31 and M33. Up to now, there have been a total of 1870 quasars discovered by LAMOST in this area. The much enlarged sample of known quasars in this area can potentially be utilized to construct a precise astrometric reference frame for the measurement of minute proper motions of M31, M33 and their associated substructures, which are vital for understanding the formation and evolution of M31, M33 and the Local Group of galaxies. Moreover, in the sample, there are a total of 45, 98 and 225 quasars with i magnitudes brighter than 17.0, 17.5 and 18.0 respectively. These bright quasars provide an invaluable sample to study the kinematics and chemistry of the interstellar/intergalactic medium of the Local Group.

Background Being the most luminous member of the Local Group and the nearest archetypical spiral galaxy, M31 serves as the best astrophysical laboratory for the studies of the physical and astrophysical of distant galaxies. Recent deep optical surveys have revealed complex substructures within hundreds of kpc of M31, with some of them stretching from M31 all the way to M33, which is about 200 kpc way (Ibata et al. 2007; McConnachie et al. 2009). Detailed chemical and kinematics investigations of M31 and its associated substructures are vital for understanding of M31, and for the theory of galaxy formation and evolution in general.

Being essentially point sources of zero proper motions (PMs), background quasars can serve as perfect reference sources for highly accurate PM measurements, provided enough of them of sufficient space density can be identified. And at the distance of M31 (785 Kpc, McConnachie et al. 2005), even a luminous red giant branch star has an *I* magnitude fainter than 20, high resolution spectroscopic determinations of their chemical composition are no easy tasks even for a 10m class telescope (Ibata et al. 2005; Gilbert et al. 2009). Absorption-line spectroscopy of bright background quasars allow one to probe the distribution, kinematics and chemical composition of the ISM associated with M31, of the Milky Way and of the IGM of the Local Group of galaxies.

Candidate Selection 1) We select low-redshift quasars candidates with *i*-band magnitude brighter than 20.0 following Richards et al. (2002) of the SDSS quasars selected algorithms. 2) For the very central area of M31 and M33, we use the data of KPNO 4m telescope survey of the Local Group Galaxies, using the transformations given by Jester et al. (2005) for z <2.1 quasars. 3) We select optical/IR quasar candidates by first selected WISE w1-w2>0.8 targets and then cross-correlated with the optical catalogs of SDSS, KPNO, XSTPS-GAC.

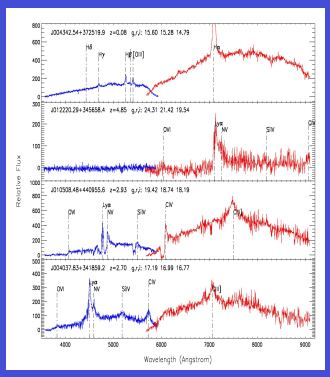
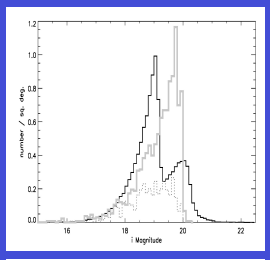
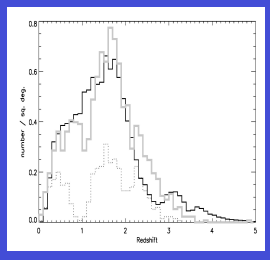


Fig.1 Example of LAMOST spectra of newly discovered quasars, with identified lines labeled.





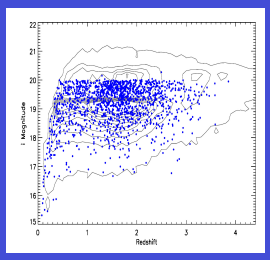


Fig.2 Comparison of LAMOST detected quasars with SDSS DR7 quasars in *i*-band magnitude space (left-up; LAMOST: grey; SDSS: black), redshift space (right up; LAMOST: grey; SDSS: black), and redshift-magnitude space (left-bottom; LAMOST: blue; SDSS: grey contours).

Results and Discussion In total 1870 quasars are discovered in the vicinity of M31 to M33 along the Giant Stellar Stream by LAMOST. The 1870 quasars have *i*-band magnitudes ranging from 14.79 to 20.0 and redshifts from 0.08 to 4.85, and represent a significant increase of the number of identified quasars in the vicinity of M31 and M33 (Fig. 1 & 3). The much enlarged sample of known quasars in the vicinity of M31 can be utilized to construct a perfect astrometric reference frame to measurement the minute PMs of M31 and M33, one of the most fundamental properties of the Local Group of galaxies, and the PM of substructures associated with the Local Group.

This sample includes 45, 98 and 225 quasars with *i* magnitudes brighter than 17.0, 17.5 and 18.0 respectively. In the aforementioned brightness bins, 15, 35 and 84 quasars are reported here for the first time, and 6, 21 and 81 are reported in our pervious work (Huo et al. 2013). In addition, 0, 1 and 6 are from the Sloan Digital Sky Survey and 24, 41 and 54 are from the NED database. Those bright quasars provide an invaluable sample to probe the kinematics and chemistry of the ISM/IGM in the Local Group of galaxies.

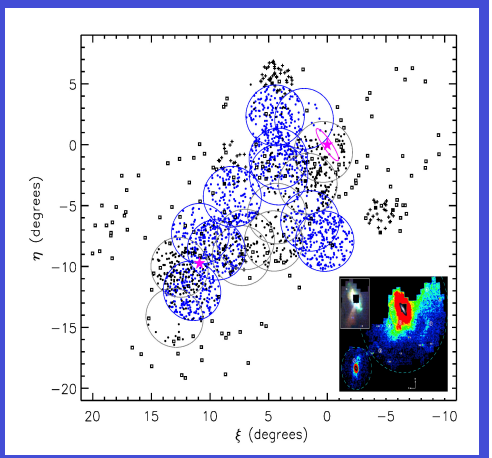


Fig.3 Spatial distributions of background quasars in the vicinity of M31 and M33. blue filled circles represent quasars identified by LAMOST in the 2013 dataset, Black filled circles represent quasars identified in the LAMOST 2009, 2010 and 2011 datasets, respectively. Pluses and open squares represent SDSS quasars and previously known quasars with redshifts archived in the NED, respectively. The magenta stars mark the central positions of M31 and M33, while the magenta ellipse represents the optical disk of M31 of radius R_{25} = 95.3′.