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THE PROPER MOTION OF THE LARGE MAGELLANIC CLOUD: A REANALYSIS

M. H. Pedreros,[1,3] E. Costa,[2,3] and R. A. Méndez[2,3]

RESUMEN

Hemos determinado el movimiento propio (p.m.) de la Nube Grande de Magallanes (LMC) con respecto a cuatro cuasares (uno por campo), combinando datos de dos estudios previos hechos por nuestro grupo y nuevas observaciones hechas en un máximo de tres épocas no incluidas en las investigaciones originales. Nuestro nuevo valor de p.m. indica que la LMC no es miembro de un propuesto alineamiento de galaxias con órbitas similares alrededor de nuestra galaxia.

ABSTRACT

We have determined the proper motion (p.m.) of the Large Magellanic Cloud (LMC) relative to four background quasi-stellar objects, combining data from two previous studies made by our group, and new observations carried out in up to three epochs not included the original investigations. Our new p.m. value indicates that the LMC is not a member of a proposed stream of galaxies with similar orbits around our galaxy.

Key Words: **ASTROMETRY — MAGELLANIC CLOUDS**

The present study (Pedreros, Costa & Méndez 2006) is a follow-up of the works by Anguita, Loyola & Pedreros (2000, hereafter ALP) and Pedreros, Anguita & Maza (2002, hereafter PAM) in which the p.m. of the LMC was determined using the "quasar method". This method, fully described in ALP and PAM, consists in using quasi-stellar objects (QSOs) in the background field of the LMC, as fiducial reference points to determine its p.m..

Here we report the results obtained combining data from previous studies by our group, with new observations, for the LMC quasar fields Q0459-6427, Q0557-6713, Q0558-6707, and Q0615-6615 (in the same nomenclature used by ALP and PAM), respectively. The original study of field Q0459-6427 was reported in PAM, and those of Q0557-6713, Q0558-6707 and Q0615-6615 in ALP.

The observational material used here amounts to a total of 47, 72, 51 and 50 CCD frames of the LMC fields around the projected quasars Q0459-6707, Q0557-6713, Q0558-6707 and Q0615-6615, observed in 9, 13, 9 and 11 epochs, respectively, ranging from January 1989 through December 2001 using a CCD camera attached to the Cassegrain focus of the CTIO 1.5 m telescope in its f/13.5 configuration.

The new data included in this study, represent a significant increase in the time baseline and in the number of observed data points, with respect to what was available for the ALP and PAM studies. This increase corresponds to a 19%, 65%, 126% and 65% in the time baseline and to a 7%, 18%, 59% and 56% in the number of available frames (corresponding to 3, 11, 19 and 18 additional frames) for the above QSO fields, respectively.

The coordinates in R.A. and DEC for the reference stars and the QSO for each image are obtained by processing the observed CCD images through DAOPHOT as a task of the IRAF package.

The resulting proper motions for the individual fields are shown in Table 1 as $\mu_\alpha \cos(\delta)$ and μ_δ in milliarcsec per year for R.A. and DEC. Columns 2 and 3 contain the measured proper motions of the field. Columns 4 and 5 correspond to the p.m. relative to the LMC's center and corrected for rotation of the LMC's plane.

The weighted averages of the proper motions obtained in this work along with those by other authors using different methods are shown in Table 2. It is clear that our results are in good agreement with those from most authors (including those obtained by PAM). On the other hand they show significant differences (especially in DEC) with those obtained by ALP.

[1]Departamento de Física, Facultad de Ciencias, Universidad de Tarapacá, Casilla 7-D, Arica, Chile (mpedrero@uta.cl).

[2]Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile (costa, rmendez@das.uchile.cl).

[3]Visiting Astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under cooperative agreement with the National Science Foundation.

TABLE 1

PROPER MOTION OF THE FIELD AND OF THE LMC'S CENTER

Field	$\mu_\alpha \cos(\delta)$ (mas yr^{-1})	μ_δ (mas yr^{-1})	$\mu_\alpha \cos(\delta)$ (mas yr^{-1})	μ_δ (mas yr^{-1})	Frames	Epochs
Q0459-6427	1.8 ± 0.2	0.1 ± 0.2	1.9 ± 0.2	0.5 ± 0.2	47	9
Q0557-6713	1.1 ± 0.2	1.9 ± 0.1	1.5 ± 0.2	1.5 ± 0.1	72	13
Q0558-6707	1.2 ± 0.2	0.6 ± 0.3	1.4 ± 0.2	0.2 ± 0.2	51	9
Q0615-6615	1.9 ± 0.2	1.4 ± 0.2	2.2 ± 0.2	0.7 ± 0.2	50	11

TABLE 2

HIGH PRECISION DETERMINATIONS OF THE PROPER MOTION OF THE LMC'S CENTER

Source	$\mu_\alpha \cos(\delta)$ (mas yr^{-1})	μ_δ (mas yr^{-1})	Proper Motion System
Kroupa, Röser & Bastian 1994 (p.m. of field)	$+1.3 \pm 0.6$	$+1.1 \pm 0.7$	PPM
Jones et al. 1994	$+1.37 \pm 0.28$	-0.18 ± 0.27	Galaxies
Kroupa & Bastian 1997 (p.m. of field)	$+1.94 \pm 0.29$	-0.14 ± 0.36	Hipparcos
ALP	$+1.7 \pm 0.2$	$+2.9 \pm 0.2$	Quasars
PAM	$+2.0 \pm 0.2$	$+0.4 \pm 0.2$	Quasars
Drake et al. 2001	$+1.4 \pm 0.4$	$+0.38 \pm 0.25$	Quasars
Kallivayalil et al. 2006	$+2.03 \pm 0.08$	$+0.44 \pm 0.05$	Quasars
This work (weighted average)	$+1.8 \pm 0.1$	$+0.9 \pm 0.1$	Quasars

Combining the components given in the last entry of Table 2, we derive a total LMC p.m. of $\mu = (+2.0\pm0.1)$ mas yr^{-1}, with a position angle of $\theta = (62.4\pm3.1)^\circ$, measured eastward from the meridian joining the center of the LMC to the north celestial pole. This result is compatible with theoretical models (Gardiner et al. 1994), which predict a p.m. for the LMC in the range 1.5$-$2.0 mas yr^{-1}, with a position angle of $\theta \approx 90^\circ$.

Lynden-Bell & Lynden-Bell (1995), have proposed that the LMC, together with the SMC, Draco and Ursa Minor, and possibly Carina and Sculptor, define a stream of galaxies with similar orbits around our galaxy. Their models predict a p.m. for each of member of the stream, which can be compared to their measured p.m. to evaluate the reality of the stream.

For the LMC they predict p.m. components of $[\mu_\alpha \cos\delta, \mu_\delta] = [+1.5, 0]$ mas yr^{-1}, giving a total p.m. of $\mu = +1.5$ mas yr^{-1}, with a position angle of $\theta = 90^\circ$. A comparison of this prediction with our result $[\mu = (+2.0\pm0.1)$ mas yr^{-1}, $\theta = (62.4\pm3.1)^\circ]$, shows that our measured values of μ and θ are, respectively, 5.1σ and 8.9σ away from the predicted values. This result indicates that the LMC does not seem to be a member of the above stream.

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