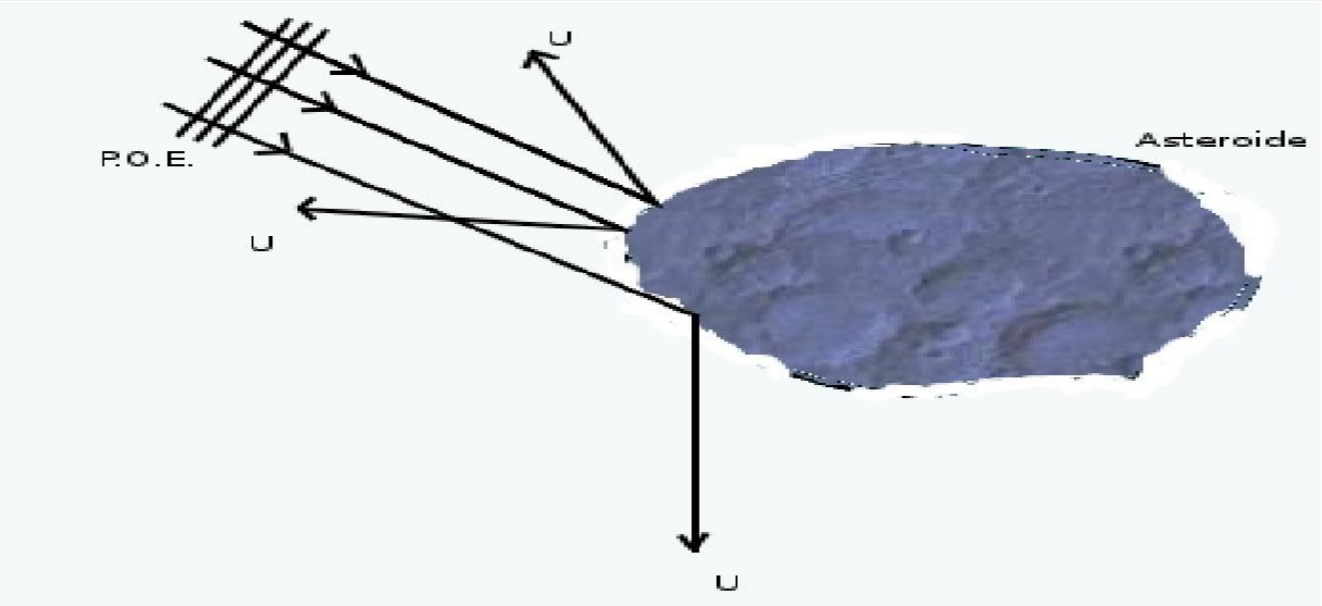
LIGHT CURVES AND COLORS OF 2060 CHIRON (1997 UB) AND 10199 CHARIKLO (1997 CU26)***

- Authors: M.Galiazzo[1,4*], G. Carraro[2,4], M. Maris[3] et al.

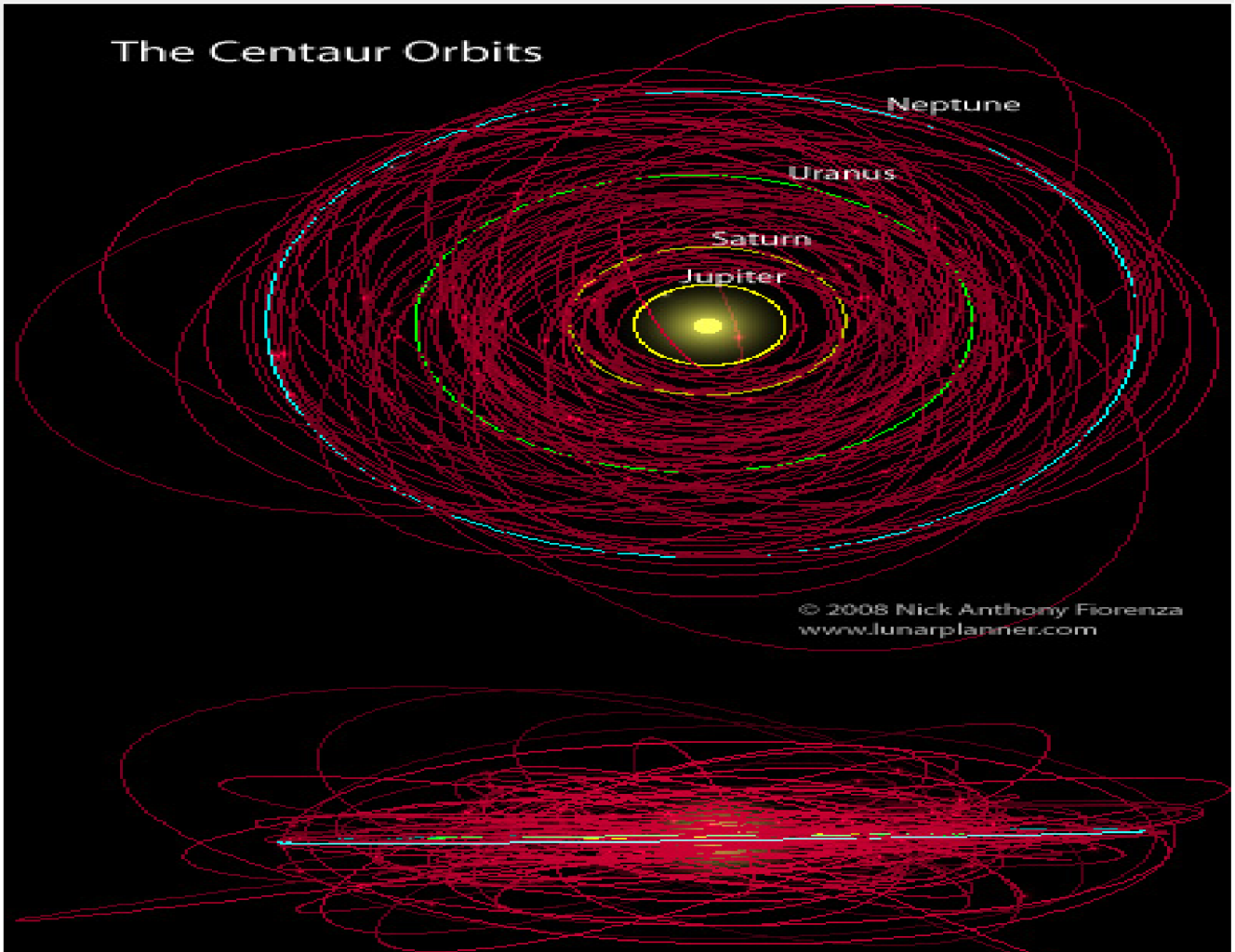
- ***PAPER SUBMITTED



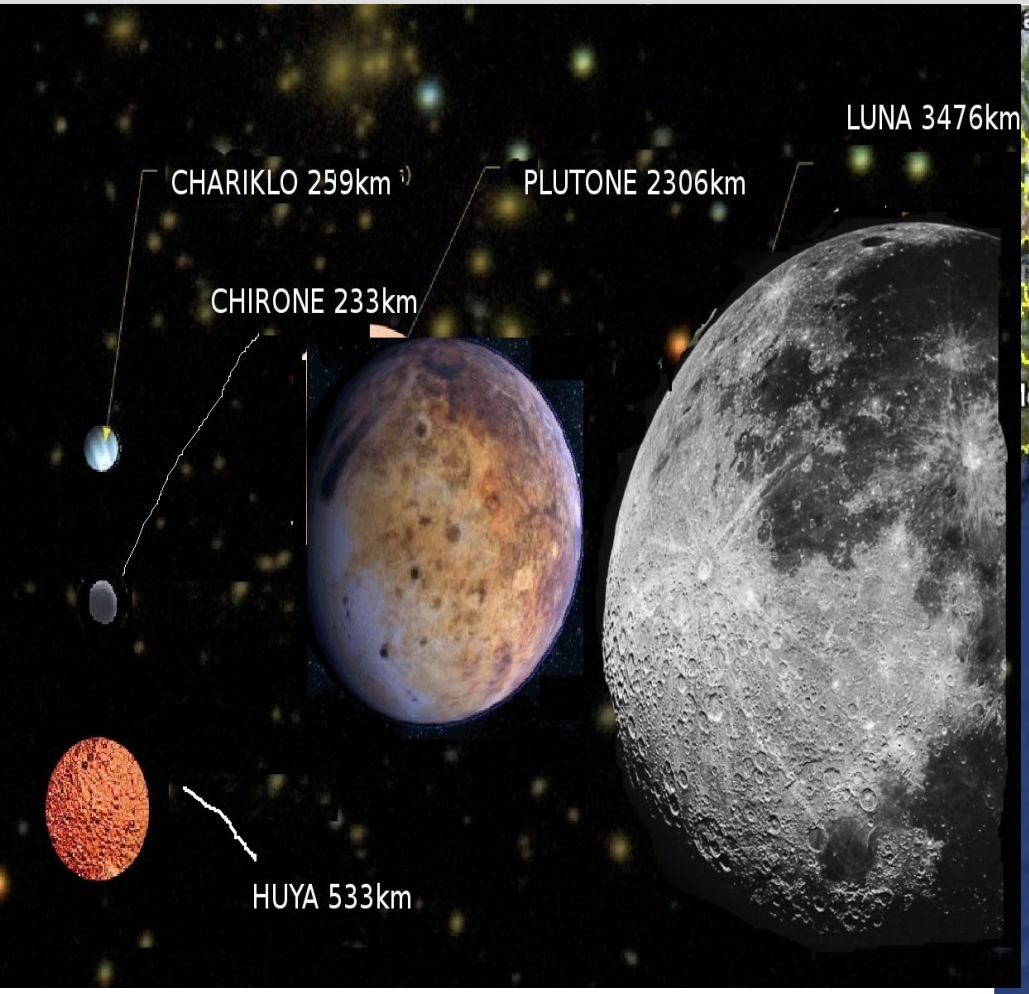
- 1 Institute for astronomy, University of **Vienna**, 2 Departamento de astronomia, Universidad de Chile (**Santiago**), 3 INAF, Osservatorio astronomico di **Trieste**, 4 Dipartimento di Astronomia, Universita' degli Studi di **Padova**

CENTAURUS

- Asteroids: Main Belt, Centaurus, TNOs (->KBOs->Plutinos)
- Comprehension of the Solar System evolution, eventual future interactions between the bodies of the system.
- Chiron and Chariklo.



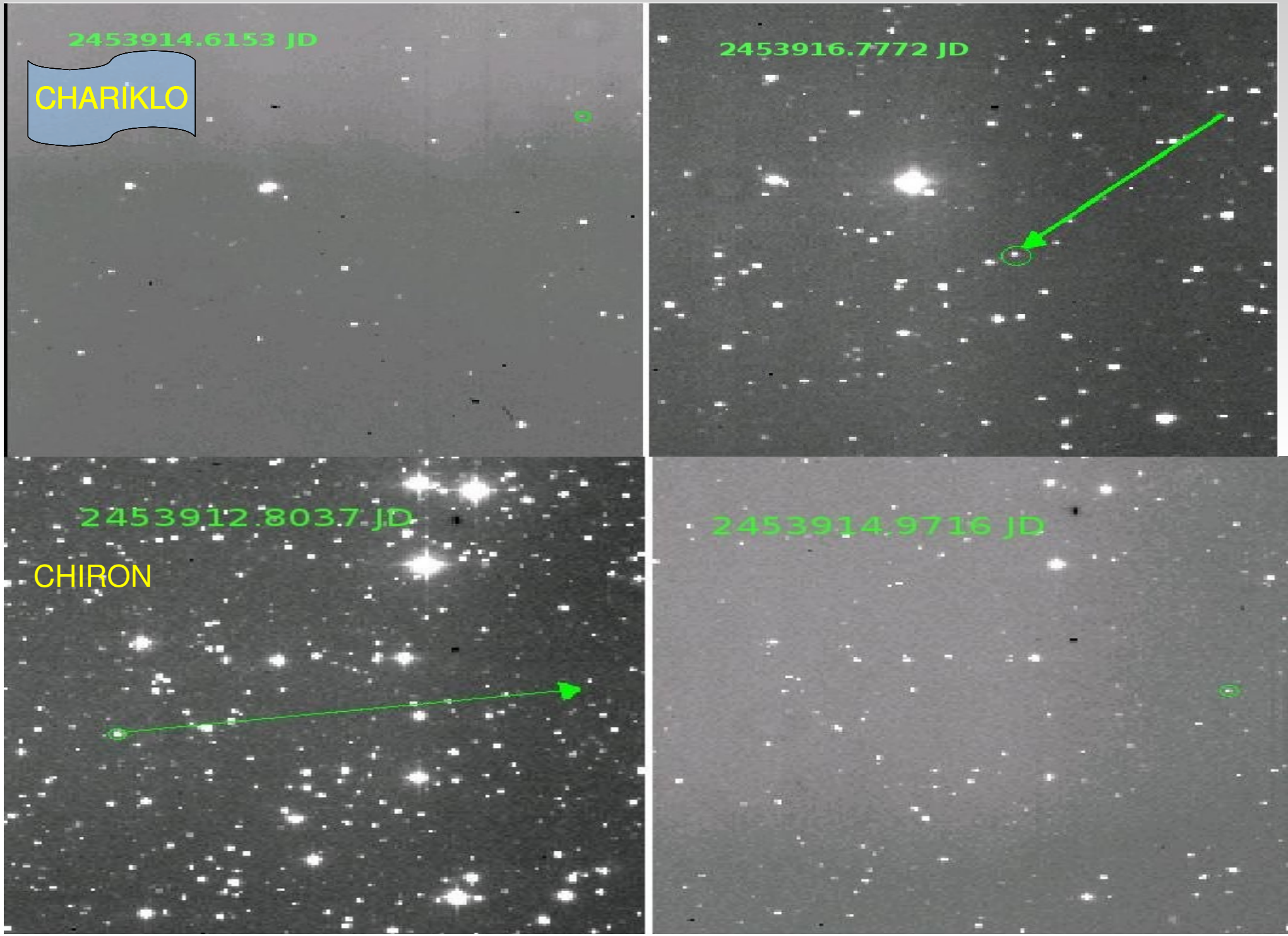
MINOR BODIES AND THEIR DIMENSIONS



TELESCOPE and OBSERVATIONS

See www.lco.cl or my master-thesis.

- G.Carraro used the Swope 1.0m Henrietta Telescope at Las Campanas – Chile and good accuracy in reduced images to frames.
- Observations: ••*Chiron* 19th of May ---> 22th of May and 26th of June ---> 30th of June 2006 •• *Chariklo* 27th of June ---> 30th of June 2006
- Field of view: 14'.8 x 22'.8
- Where: ••*Chiron* in Ophiucus ~20h 36m -11° 00' ••*Chariklo* in Hydra ~12h 24m -28° 26'
- "Field trip" of this planets...


2453914.6153 JD
CHARIKLO
2453916.7772 JD
2453912.8037 JD
CHIRON
2453914.9716 JD

GOALS

- Photometric observations —> proceeds of the asteroids **luminosity** and **colors** (—> color indexes). [Johson-Cousin (BVRI) System]
- Analisys of the possible photometric minor bodies variability -- >**ROTATIONAL PERIOD+*ESTIMATED DIAMETER FOR CHARIKLO***
- Light curve of Chiron of the last 20 years and brief analysis
- $\alpha \rightarrow 0$ (OPPOSITION SURGE) → study of the solar radiation incident on Chariklo.
- Development and implements → precision-photometric

ACCURACY ACHIEVED

Object	$<M_R>$	$<\Delta M_R>$
CHIRON	16.948	0.025
CHARIKLO	18.107	0.025

There is not the contribution of the control stars-error.

- Absolute photometry better than the differential one if the the sky is in optimal photometrical conditions and the background of the sky is homogeneous.
- Possible Max accuracy < centesimal: (Huya) 0.008m (another research of us with these methods and same telescope).

BASIC FORMULAS

$$H = H_R(\alpha) + 2.5\log[(1-G)\Phi_1(\alpha) + G\Phi_2(\alpha)] \quad (1)$$

$$\Phi_i = e^{-A_i[\tan(\alpha/2)]^{B_i}}$$

$$m_R = m_\odot - 2.5\log\left[\frac{\rho_R r^2 \phi(\alpha)}{2.25\cdot 10^{16} R^2 \Delta^2}\right] \quad (2)$$

$$M = m - 5log_{10}(D/10) \quad (3)$$

$$m_R(1,1,0) = m_R - 5log_{10}(R_{AU}\Delta_{AU}) - \Phi(\alpha) \quad (4)$$

$$\frac{a}{b} = 10^{0.4\Delta m_R} \quad (5)$$

$$log(p_V D^2) = 6.259 - 0.4H(\alpha) \quad (6)$$

$$D(km) = \frac{1.33\cdot 10^3}{\sqrt{p_V}} 10^{-0.2H(\alpha)} \quad (7)$$

PHYSICAL DATA RESULTS

BODY	$\langle\alpha_R\rangle$	$\langle\Delta\rangle$	$\langle H_R\rangle$	P
CHIRON	3.87°	13.74 A.U.	5.31 ± 0.01 m	5.91 ± 1.63 h
CHARIKLO	3.09°	12.98 A.U.	6.60 ± 0.02 m	~3.2 ± 0.5 h

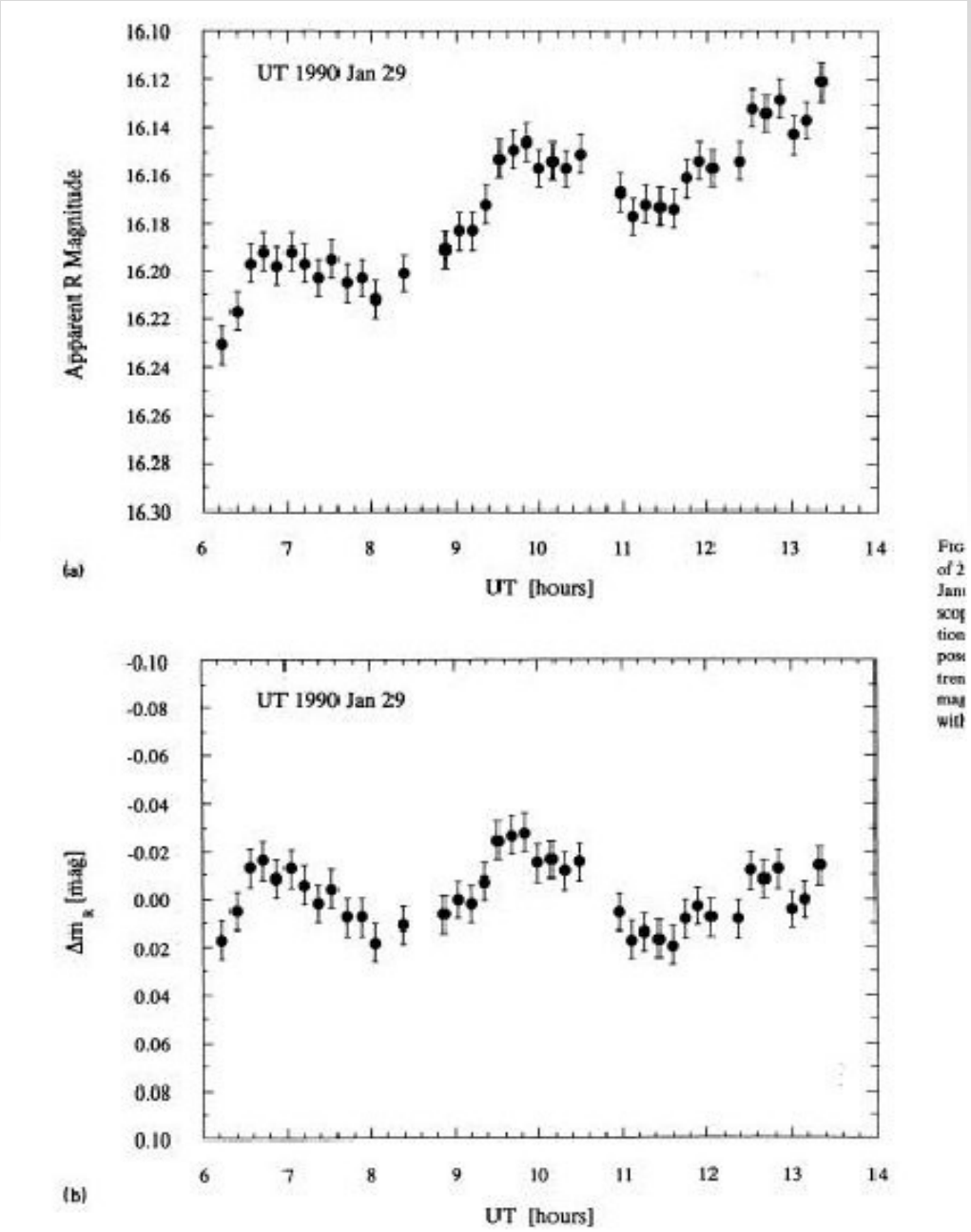
	Δm	a	b
CHIRON	0.035	~ 133.9*	~ 129.6*
CHARIKLO	0.052	~ 116.3*	~ 110.9*

	$\langle H_V(\alpha)\rangle$	D	V	M
CHIRONE	5.94 ± 0.02	317.55 ± 34.35(✵) *	$1.703 \cdot 10^{7}$*	$1.002 \cdot 10^{19}$ *
CHARIKLO	6.97 ± 0.09	227.21 ± 12.97	~ $0.629 \cdot 10^{7}$*	~$1.293 \cdot 10^{19}$*

*=another job

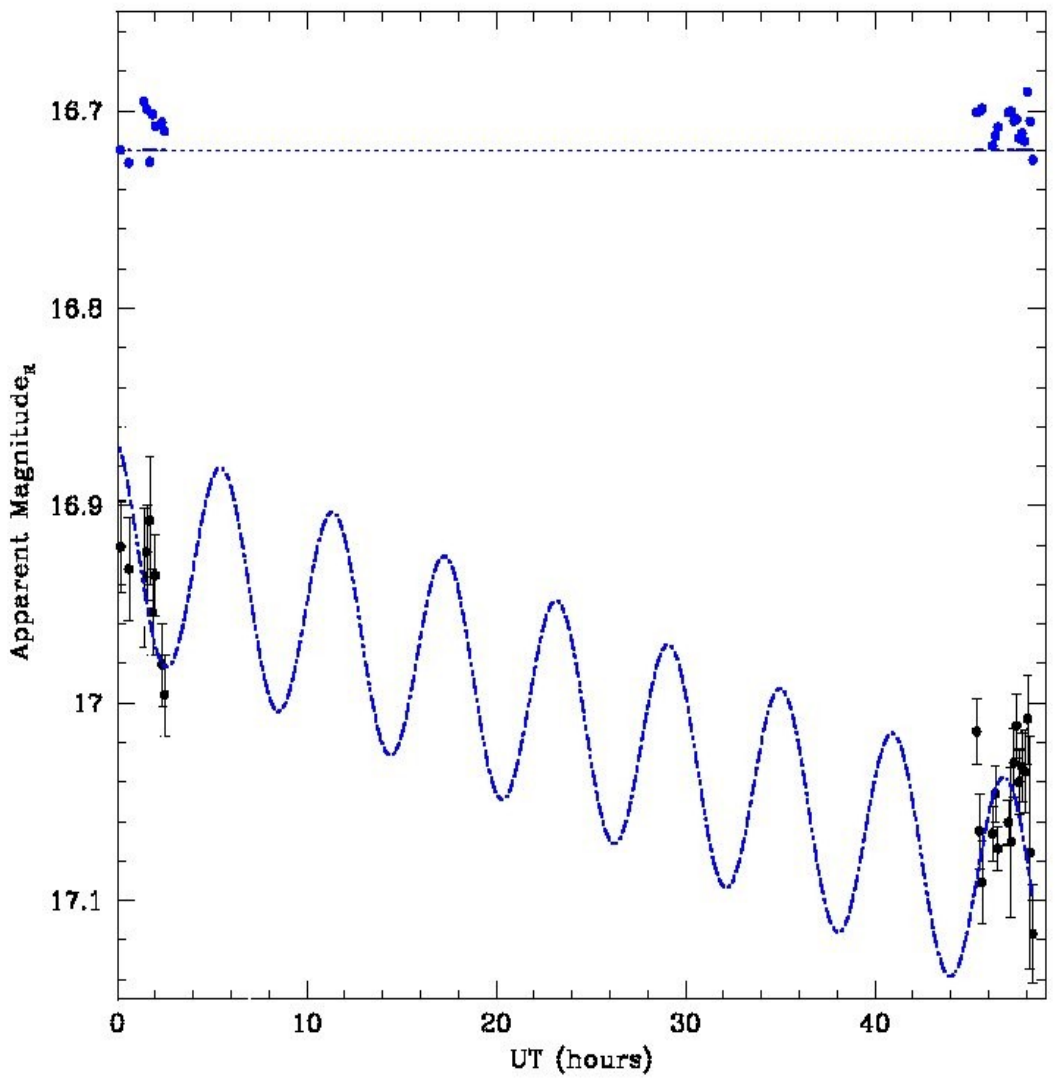
✵ = probable contribution of the coma

CHIRON- LIGHT CURVE



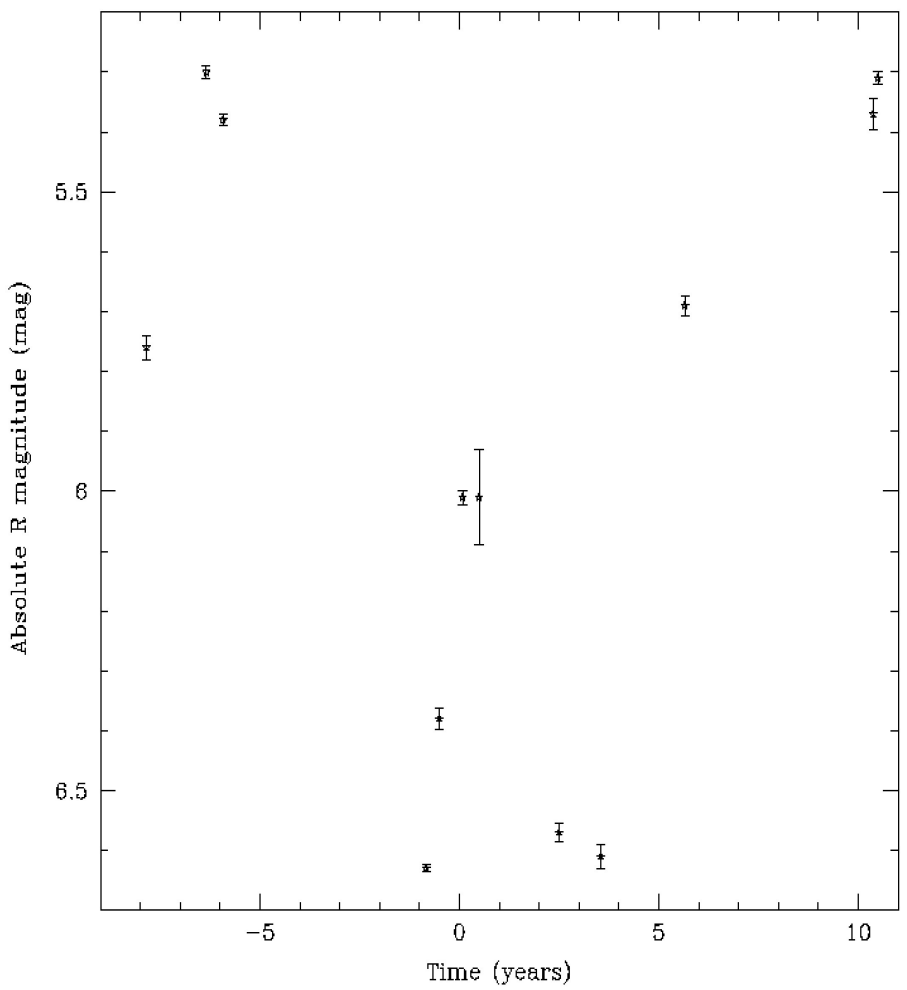
- LITERATURE DATA
- Luu&Jewitt(1990):
  P= 5.91780 ± 0.00005 h.
  A=0.045
- Raw data.
- Scaled data → Linear increase of luminosity.
- Lazzaro(1997):
  P=5.9178± 0.0015
  A=0.06

CHIRON-LIGHT CURVE



- <u>OUR DATA</u>
- P=(5.91±1.63) h
  A=(0.056±0.003) m
- Average error-bar = 0.039m.

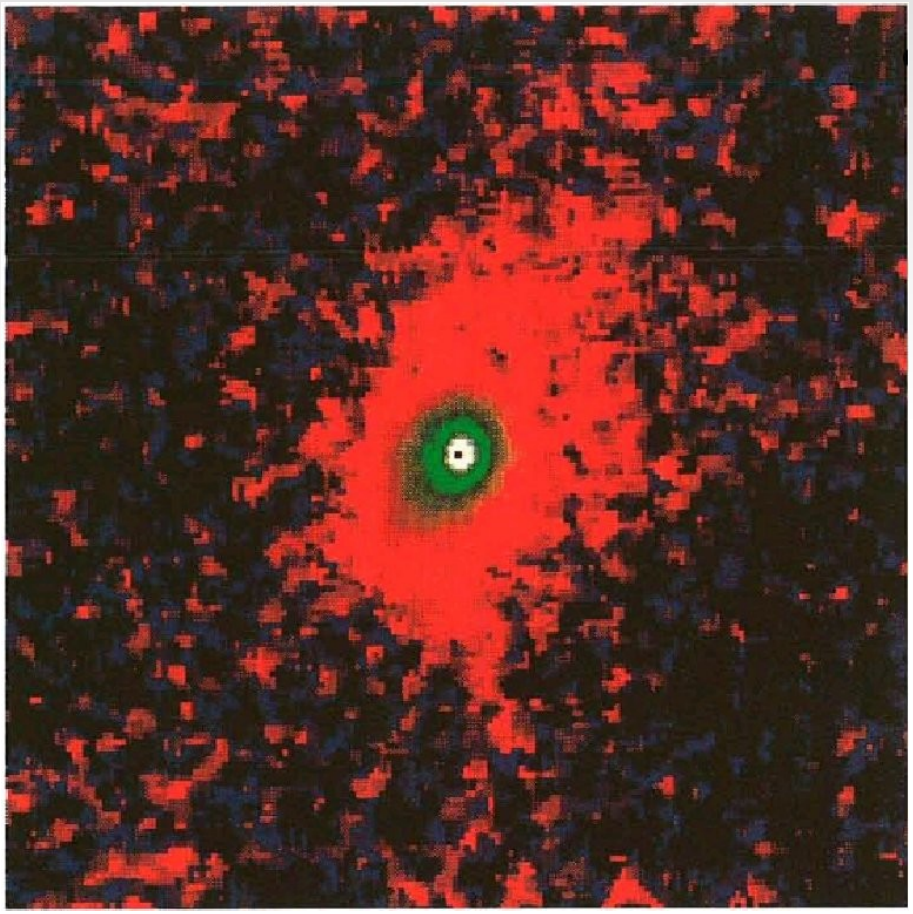
CHIRON COMETARY ACTIVITY



$$H_R(\alpha) = m_R - 5\log(r\Delta)$$

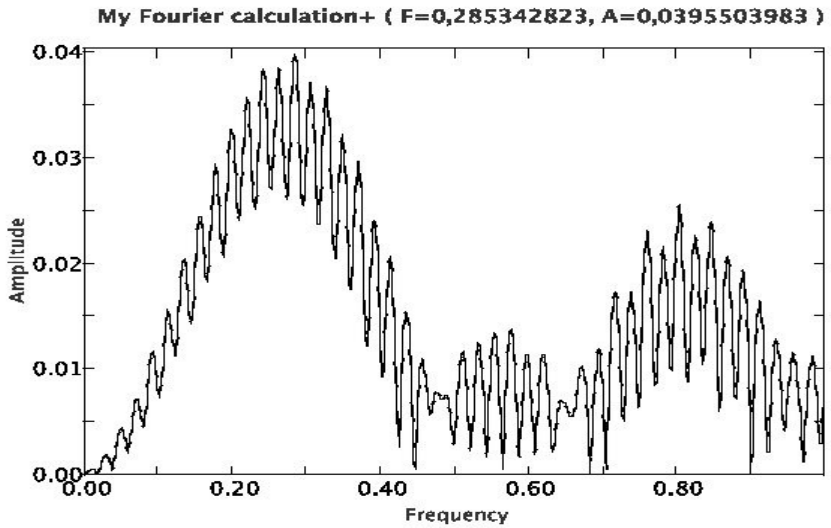
- Absolute R magnitude of Chiron from 1988 to 2006.
- Zero-point = Jan. 1st 1996. Relevant : local max 1996 and 3 local max points: 1991 and 2006. Our datum: (**5.31±0.01**)m .
- Meech&Belton1989 (first observation of its activity).
- Luu&Jewitt1990:variation of luminosity at low-high rate.
- Marcialis 1993:long-obs. → realise of volatile gas(CN,CO_2)

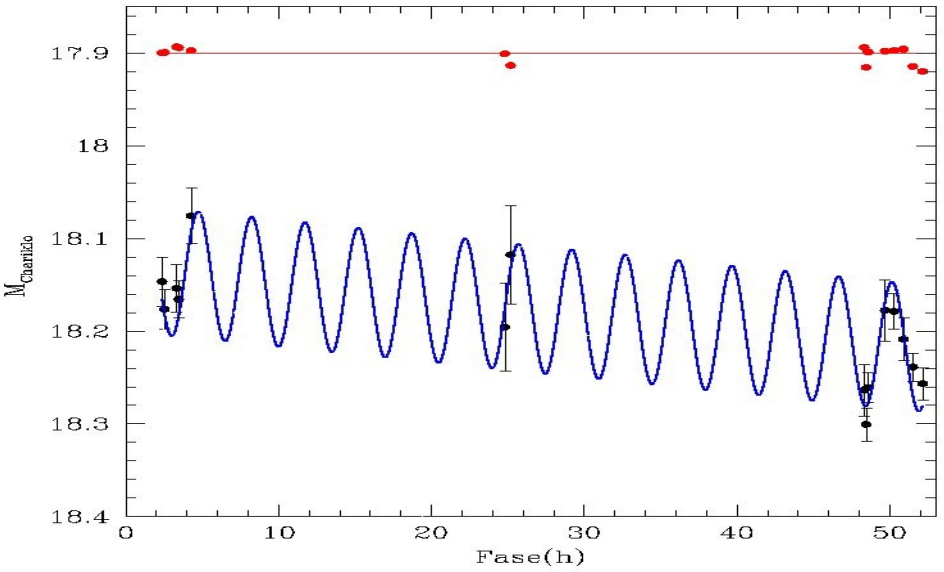
OVERIMPOSITION OF FRAMES IN DIFFERENT PHASE-TIMES



- Meech+Belton 1989: over imposition of 20 frames with a total integration of 107min.
- 70x70 arcsec^2

CHARIKLO-LIGHT CURVE





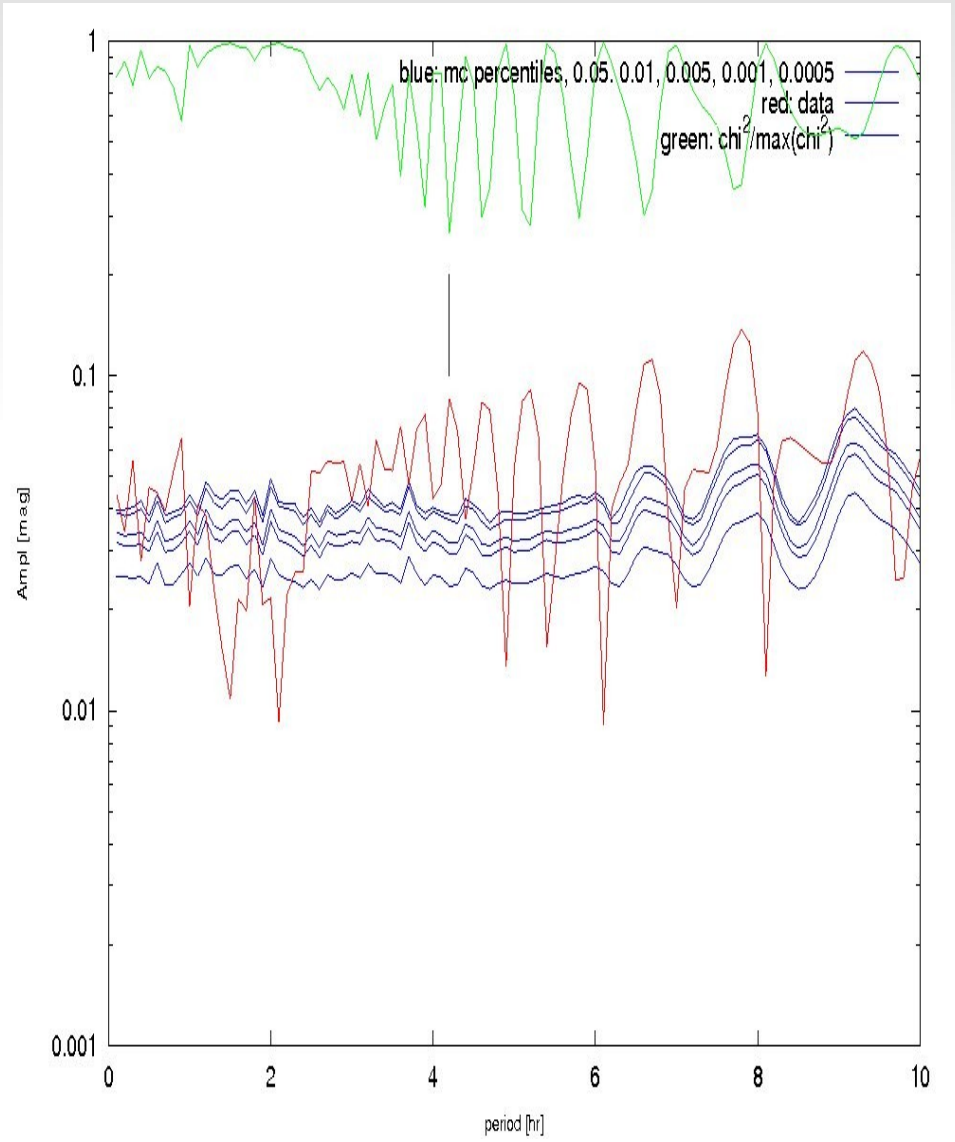
- Peixinho=>18.5 (50%)
- Few data ---> light curve with mainly 3 different statistical methods:

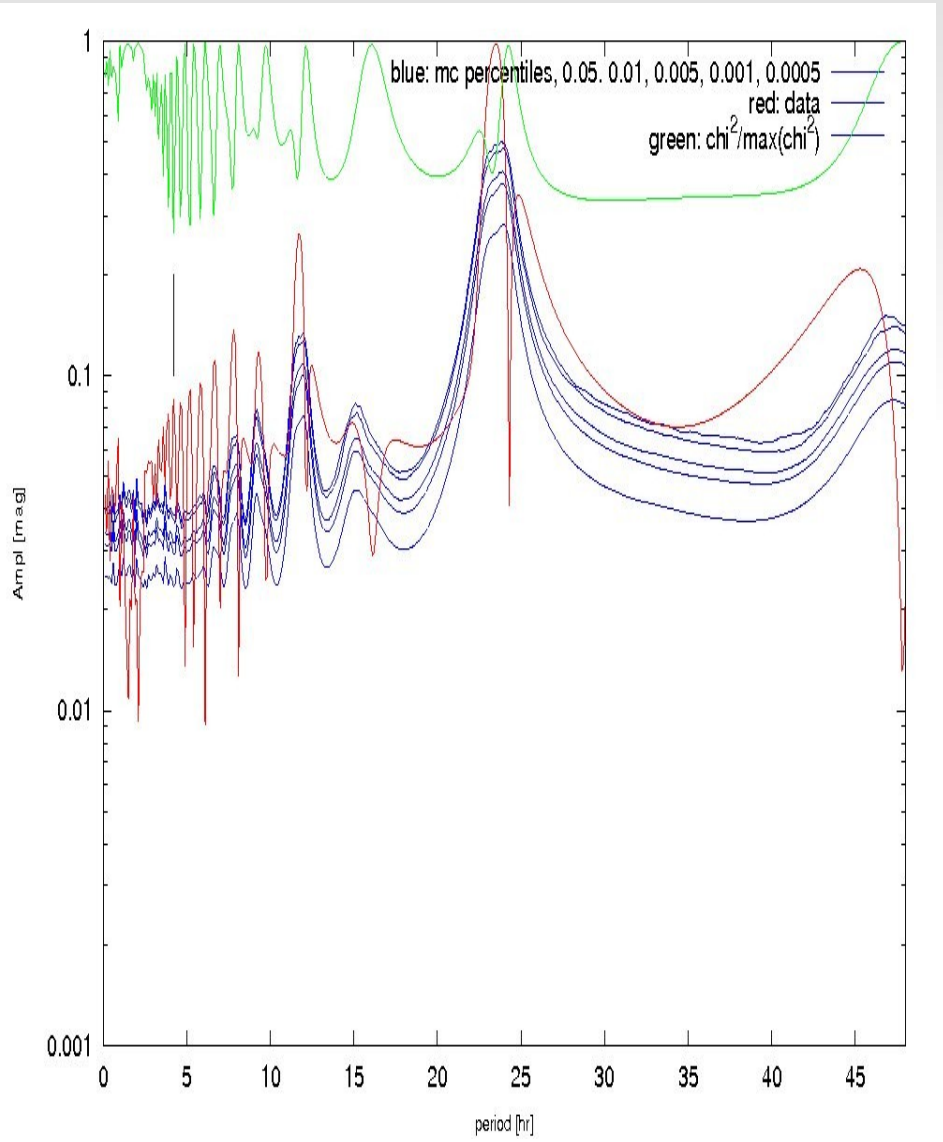
  1) $R(t) = C \cos(2\pi t/P) + S \sin(2\pi t/P) + mt + R_0$;

  2)Period04: based on the (DFT).

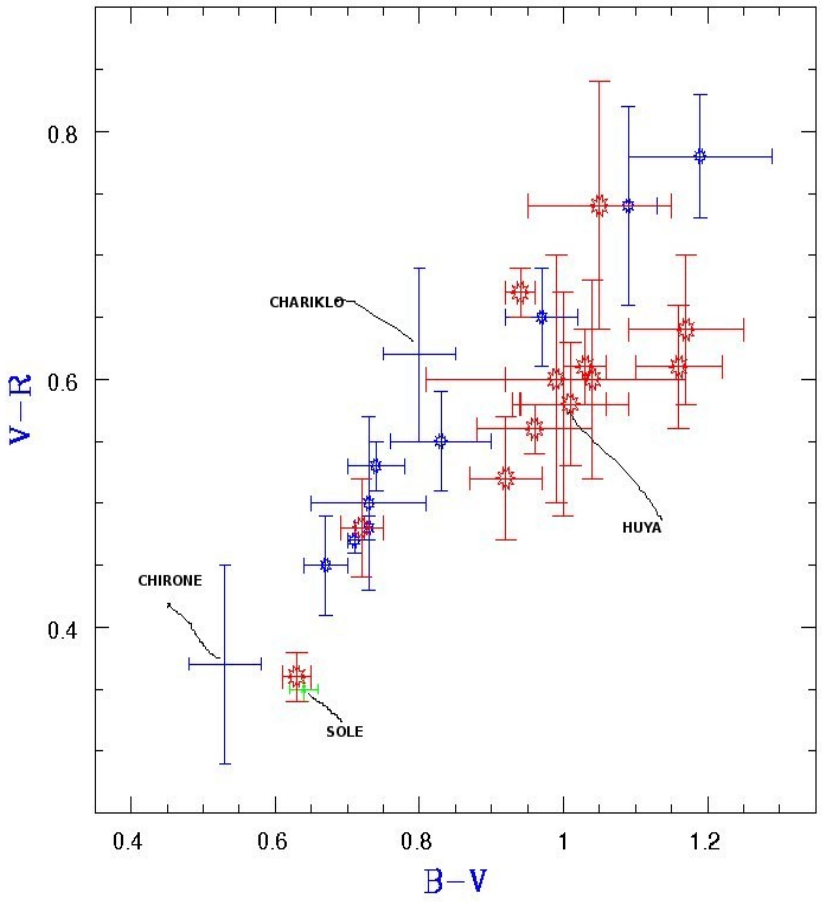
  3)z_compet.macro: fitting with a sinusoidal function + linear trend with a classical weighted mean squares fit. $R(t)=A\sin(kt + w) + R_0 + M * t$; (Limits of the current time series, the best chi-square (chi=12.04)).

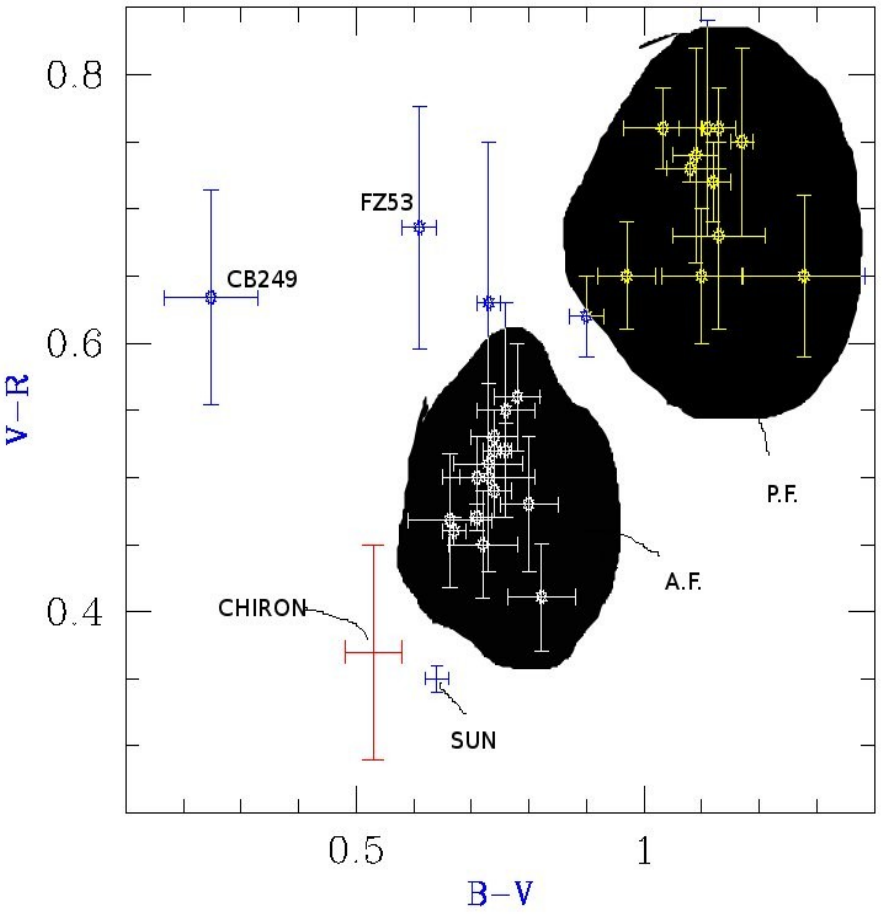
Example (method 1 – raw data → not considering the drifts): Chi-square + Time window





COLORS ANALYSIS





CONCLUSIONs

- Chiron has a strong dual behavior which influence a lot its variation of luminosity and because it is so different with the others, probably it had great interactions with other bodies in the past..
- **We had obtained a good photometry with few data too, having implemented photometry taking with a program made by M.Galiazzo, which takes the least variable stars in luminosity and testing a couple of methods analyzing the light curve by studying the chi-square and the time windows (M.Maris).**
- **Looking very deep in our photometry we may take in consideration that Chariklo could have a satellite or perhaps a cometary activity too. To check this it is ought to be done more observations at difference phases and distances. Just the same for the extension of Chiron-coma.**