#### From AGB stars to Cepheids

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#### **Overview Talk**

- Herschel-PACS, GAIA, VMC
- The distance to the Galactic Centre (Gr., Udalski, Bono, 2008, A&A 481, 441)

#### Herschel

4th ESA Cornerstone mission Launch (not before) January 2009

PACS - SPIRE - HIFI70-110-170250-350-500  $\mu$ m filters60-210200-670  $\mu$ m spectroscopyHIFI 7-bands that cover 157-213, 236-625  $\mu$ m

Belgium 20% Co-PI in PACS (C. Waelkens) IMEC, CSL, IvS (ICC)

#### PACS GT

Belgian Guaranteed Time: 380 hours

involved in GTKP: Nearby Galaxies (50h Gent) Quasars (30h IAGL) Star Formation, Debris disks (70h, KUL) Solar System (20h, KUL)

PI. of GTKP on post-main-sequence objects (140h) ROB, IvS, IAGL (Vienna, Heidelberg, SAG6)

## PACS GTKP

In its most general terms this GT KP aims at studying the ....

• Circumstellar matter in evolved objects

AGB, RSG, Post-AGB, PNe, WR, LBV, SN

- Photometric mapping of nearby objects
- Spectroscopy of nearby objects

## Mapping of nearby objects

Goal: Study

Study of asymmetries in, and the time evolution of, the mass-loss process in post-MS objects

- Well studied process in optical and NIR, but non-optimal wavelength region
- IRAS: poor resolution
- ISO also gave few results (PHOT32 mode difficult to calibrate; poor resolution and mapping area)
- PACS/SPIRE resolution begins to approach that of current mm-interferometers



Fig. 1. 90  $\mu$ m image of YCVn taken with PHT-CI 00 array detector and C90 filter displayed in linear brightness scale.



Fig. 2. 160 µm image of Y CVn taken with PHT-C200 array detector and C160 filter displayed in linear brightness scale.

#### Y CVn; Izumiura et al. (1996), $8' \times 35'$ PHT32 map

#### Implementation

PACS: Maps at 70 + 170  $\mu$ m. PACS: 78 AGB/RSG, 16 post-AGB/PN, 8 WR/LBV

SPIRE: default is all 3 wavelengths

SPIRE GT: 27 targets, also observed with PACS (+5 SNe observed with PACS + SPIRE)

(Because of time limitation and flux-levels a larger overlap between PACS and SPIRE could not be achieved).

## **Spectroscopy of nearby objects**

# Goal: Study of dust properties, molecular lines, emission lines



NGC 6302; Molster et al., SWS + LWS spectrum Brussels, 6 May 2008 – p.9/3:

#### **Dust and Ices in FIR**

mineral	chemical	'60+' band
	formula	positions [ $\mu$ m]
fosterite	$Mg_2SiO_4$	69–70
fayalite	$Fe_2SiO_4$	93–94, 110
diopside	$CaMgSi_2O_6$	65-66
calcite	CaCO <sub>3</sub>	92
dolomite	$CaMg(CO_3)_2$	62
graphite	С	50–70
water ice	$H_2O$	62
methanol ice	$lpha$ -CH $_3$ OH	68, 88.5
dry ice	$CO_2$	85
PAHs "flopping modes"		(far-IR)

#### **Molecular- and emission lines**

[O I]	63.184
[Si I]	68.473
[O III]	88.35
[N II]	121.898
[Si I]	129.682
[O I]	145.525
[C II]	157.74
CO(13-12)	200.3
CO(40-39)	65.
$H, H_2O, NH_3, CH, HCN$	

#### Implementation

PACS: Cover entire 60-210  $\mu$ m at Nyquist sampling Spatial information: 5 × 5 pixels = 47" × 47" PACS GT: 27 AGB/RSG, 26 post-AGB/PN, 2 WR/LBV SPIRE GT: 23 targets also observed with PACS

SPIRE GT: 23 targets, also observed with PACS (+1 SN with SPIRE and 3 with PACS)

#### GAIA

Member of CU7 WP on specific object studies

• LPV (Thomas Lebzelter; A. Jorissen)

• RR Lyrae and Cepheids (Gisella Clementini)

CU7-3 meeting in Leuven (Nov 06) scientific interest: distance scale (Cepheids, RR Lyrae), LPVs, EB (combining  $LC + RV + T_{eff}$ )

#### VMC

VMC = VISTA Magellanic Cloud Survey PI. Maria-Rosa Cioni (University of Hertfordshire)

- VISTA
- 1 of 6 selected Public Surveys
- Survey in YJK of LMC, SMC, Bridge & Stream

#### VISTA

- The Visible & Infrared Survey Telescope for Astronomy (VISTA)
- Originally the result of an application of Queen Mary University of London on behalf of a consortium of 18 Universities to the UK Joint Infrastructure Fund that was approved in summer 1999
- To be placed on Cerro Paranal and ESO would get a certain fraction of the time
- With the UK joining ESO, VISTA became part of the in-kind contribution



#### VISTA

- 4.0m primary mirror
- 16 2048  $\times$  2048 pixel CCDs with 0.34" pixels
- Z, Y, J, H, K + narrow-band



Brussels, 6 May 2008 – p.17/3

#### VISTA

•  $3 \times 2$  steps in X and Y



• light green corresponds to  $1.5 \times 1.0$  degree

• jitter for bad pixels and sky

#### **ESO Public Surveys**

- 1990's: ESO Imaging Survey (EIS)
- VST: 3 PS selected in November 2005

P.I. Kuijken et al.KIDS: A 1500 square degree cosmological survey4800h over 8 semesters

P.I. Drew et al. VPHAS+, the VST photometric  $H\alpha$  and broad-band survey of the Southern Galactic Plane 840h over 6 semesters

P.I. Shanks et al.The VST ATLAS544h over 4 semesters

#### **ESO Public Surveys**

#### • VISTA

75% of observing time available for PS CfP, deadline March 15, 2006 15 proposals submitted, and reviewed by PSP 10 pre-selected, suggestions for "mergers and marriages" to give 6 proposals final proposals submitted to P79 OPC selection, and setting-up and approval of SMP in 2007 (2008)

#### **VISTA PS selected**

VISTA Hemisphere Survey (VHS) VISTA Kilo-degree Infrared Galaxy survey (VIKING) VISTA Deep Extragalactic Observations (VIDEO) Survey UltraVISTA Deep Survey in the COSMOS field VISTA Variables in the Via Lactea (VVV) VISTA near-infrared YJK survey of the Magellanic System (LMC, SMC, Bridge & Stream) - VMC

#### **VISTA PS pointings**



## **VMC** pointings



• VST pointings within STEP GTO

#### VMC

- Total area 184 sq.degrees = 110 tiles
- S/N = 10 at Y = 21.9, J = 21.4, K = 20.3
- 300h in P82,84,86,88,90 + 72h in P83,85,87,89,91 = 1815 hours = 200 n
- First Consortium meeting April 7-8, 2008
- Start in January 2009, first reduced data from mid-2009 onwards

#### • VDFS:

Cambridge Astronomical Survey Unit (CASU) Wide Field Astronomy Unit (WFAU)

#### **VMC: science**

- Primary science goal: determine spatially resolved SFH
- Interaction of MCs
- 3D picture of MCs: red clump, RR Lyrae and Cepheids (12 epochs in *K*)
- AGB, post-AGB, PNe
- Combine with Spitzer (SAGE & S<sup>3</sup>MC), Akari, Herschel (OTKP) & OGLE-III, super-MACHO
- My interest: SED fitting Mass-loss as a function of pulsation, luminosity, metallicity

#### **Distance to GC**



Eisenhauer et al. 2005 ApJ 628, 246  $R_0 = 7.62 \pm 0.32$  kpc

Brussels, 6 May 2008 - p.26/33

#### **Overview Distances**

Reid (1993)	Review	$8.0\pm0.5$
Eisenhauer et al. (2005)	BH	$7.62\pm0.32$
McNamara et al. (2000)	$\delta$ Scu	$7.9\pm0.3$
Collinge et al. (2006)	RR Lyrae	$8.8\pm0.3$
Carney et al. (1995)	RR Lyrae	$8.3 \pm 1.0$
Fernley et al. (1987)	RR Lyrae	$8.0\pm0.65$
Groenewegen & Blommaert (2005)	Mira	8.5 to 9.0
Feast & Whitelock (1997)	Cepheid pm	$8.5\pm0.5$
Vanhollebeke et al. (2008)	pop. synthesis	$8.60\pm0.50$
Paczynski & Stanek (1998)	Red Clump	$8.4\pm0.4$
Nishiyama et al. (2006)	Red Clump	$7.5 \pm 0.4$
Babusiaux & Gilmore (2005)	Red Clump	$7.7 \pm 0.15$

## **Type-II Cepheids**

Population-II Cepheids are old, low-mass stars After the exhaustion of core He-burning, move toward lower  $T_{\rm eff}$ , thus crossing the Cepheid instability strip Intermediate in properties between RR Lyrae and classical  $\delta$  Cepheids They obey a Period-Luminosity relation (in K) ! Kubiak & Udalski (2003) have searched the OGLE-II database for P2C Cepheids and found 54 objects 70 could be added from OGLE-III

## **OGLE Lightcurves**



#### P = 0.76 days

#### P = 9.94 days

#### Observations

SOFI @ NTT/La Silla. June 24, 28, July 3, 8 2007 DIT= 1.2 sec using a pixelscale of 0.288'' and resulting in a field-of-view of almost  $5 \times 5$  arcmin. The "auto-jitter" observing block was used with 9-13 exposures. ESO SOFI pipeline **DoPhot** for source extraction Match sources with 2MASS objects and determine off-set with instrumental magnitude 362 epochs of data of 39 P2C 32 RR Lyrae happen to be in the field !

#### **Lightcurves P2C**



## **Lightcurves RRL**



#### **PL-relations**



#### **Distance to GC**

*PL*-relations give relative distances Calibrating relations: T2C: Matsunaga et al., GCC,  $M_V$ -metallicity HB, tied to MS fitting. GC:  $14.51 \pm 0.12 \pm 0.07$ RRL: Sollima et al., GC, tied mainly to HST parallax of RR Lyra GC:  $14.48 \pm 0.17 \pm 0.07$ Averaged:  $14.50 \pm 0.10$  (random)  $\pm 0.07$  (syst.), or  $7.94 \pm 0.37 \pm 0.26$  kpc. (on a scale where the LMC has  $18.50 \pm 0.07$ )

## THE END