

Stellar variability in the VVV survey: overview and first results

M. Catelan^{1,2}, D. Minniti^{1,2}, P. W. Lucas³, I. Dékány^{1,2},
R. K. Saito^{1,2,4}, R. Angeloni^{1,2}, J. Alonso-García^{1,2}, M. Hempel^{1,2},
K. Helminiak^{1,2,5}, A. Jordán^{1,2}, R. Contreras Ramos^{1,2},
C. Navarrete^{1,2}, J. C. Beamín^{1,2}, A. F. Rojas^{1,2}, F. Gran^{1,2},
C. E. Ferreira Lopes^{1,2,6}, C. Contreras Peña³, E. Kerins⁷,
L. Huckvale^{7,8}, M. Rejkuba⁸, R. Cohen⁹, F. Mauro⁹, J. Borissova¹⁰,
P. Amigo^{1,2,10}, S. Eyheramendy¹¹, K. Pichara¹², N. Espinoza^{1,2},
C. Navarro^{1,2,10}, G. Hajdu^{1,2}, D. N. Calderón Espinoza^{1,2},
G. A. Muro^{1,2}, H. Andrews^{1,2,13}, V. Motta¹⁰, R. Kurtev¹⁰,
J. P. Emerson¹⁴, C. Moni Bidin^{2,15}, and A.-N. Chené¹⁶

¹Pontificia Universidad Católica de Chile, Instituto de Astrofísica, Santiago, Chile
email: mcatelan@astro.puc.cl

²The Milky Way Millennium Nucleus, Santiago, Chile

³University of Hertfordshire, Hatfield, UK

⁴Universidade Federal de Sergipe, São Cristóvão, SE, Brazil

⁵Nicolaus Copernicus Astronomical Center, Toruń, Poland

⁶Universidade Federal do Rio Grande do Norte, Natal, Brazil

⁷The University of Manchester, Manchester, UK

⁸European Southern Observatory, Garching, Germany

⁹Universidad de Concepción, Concepción, Chile

¹⁰Universidad de Valparaíso, Valparaíso, Chile

¹¹Pontificia Universidad Católica de Chile, Departamento de Estadística, Santiago, Chile

¹²Pontificia Universidad Católica de Chile, Facultad de Ingeniería, Santiago, Chile

¹³Leiden Observatory, Leiden, The Netherlands

¹⁴Queen Mary, University of London, London, UK

¹⁵Instituto de Astronomía, Universidad Católica del Norte, Antofagasta, Chile

¹⁶Gemini Observatory, Hawaii, USA

Abstract. The Vista Variables in the Vía Láctea (VVV) ESO Public Survey is an ongoing time-series, near-infrared (IR) survey of the Galactic bulge and an adjacent portion of the inner disk, covering 562 square degrees of the sky, using ESO's VISTA telescope. The survey has provided superb multi-color photometry in 5 broadband filters (Z , Y , J , H , and K_s), leading to the best map of the inner Milky Way ever obtained, particularly in the near-IR. The main part of the survey, which is focused on the variability in the K_s -band, is currently underway, with bulge fields observed between 34 and 73 times, and disk fields between 34 and 36 times. When the survey is complete, bulge (disk) fields will have been observed up to a total of 100 (60) times, providing unprecedented depth and time coverage in the near-IR. Here we provide a first overview of stellar variability in the VVV data.

Keywords. surveys, stars: novae, cataclysmic variables, stars: rotation, stars: spots, stars: variables: Cepheids, other

1. Overview

The VVV survey (Minniti *et al.* 2010, Catelan *et al.* 2011, Saito *et al.* 2012) has been monitoring the bulge and the southern disk in the K_s -band since 2010. It will provide, for the first time, a homogeneous database of long-baseline time-series photometry with up to 100 epochs for nearly 10^9 point sources. At present, when the extensive monitoring of the bulge fields has started, VVV has already provided a considerable number of epochs, suitable for analyses of stellar variability (Catelan *et al.* 2013). VVV provides a sparse time sampling, usually a single epoch for a few fields on a night (with an occasional second visit), distributed almost randomly over the seasonal visibility period of the area. Most of the currently available time-series data were taken in the third year of observations. An extensive overview of stellar variability in the current VVV Survey data, including detailed descriptions of the data, cadence, completeness, reduction and analysis techniques, and our efforts towards the automated classification of the VVV light curves, has recently been provided by Catelan *et al.* (2013), where one can also find examples of recent applications of these data, particularly in the context of Galactic structure. Sample light curves for many different variable star classes, including RR Lyrae, Cepheids (both classical and type II), long-period variables, eclipsing binaries, RS CVn systems, microlenses, novae, and transient events, are also provided.

2. Conclusions

VVV provides a treasure trove of scientific data that can be exploited in numerous scientific contexts. In terms of stellar variability, the project will provide up to several million (Catelan *et al.* 2013) calibrated K_s -band light curves for genuinely variable sources, including pulsating stars, eclipsing systems, rotating variables, cataclysmic stars, microlenses, planetary transits, and even transient events of unknown nature. At present, with the data-gathering phase of the VVV Survey having just crossed its half-way mark, we are really just taking the first steps in what will certainly be a long and exciting journey, during which it will be possible to address a myriad of time-domain astronomical applications. The latter include not only research on variable stars as such, but also their use as distance indicators and tracers of Galactic structure, origin, and evolution. Since VVV is a Public Survey, the data will quickly be made available to the entire astronomical community, opening the door to many additional applications and synergies with other ongoing and future projects that target the same fields as those covered by VVV.

Acknowledgements. This work is supported by the European Southern Observatory; the Basal Center for Astrophysics and Associated Technologies (PFB-06); the Chilean Ministry for the Economy, Development, and Tourism's Programa Iniciativa Científica Milenio through grant P07-021-F, awarded to The Milky Way Millennium Nucleus; and Fondecyt through grants #1110326 (M.C., I.D., J.A.-G.), 1120601 (J.B.), 1130140 (R.K.), 3130320 (R.C.R.), and 3130552 (J.A.-G.). C. Navarrete acknowledges grant CONICYT-PCHA/Magíster Nacional/2012-22121934.

References

- Catelan, M., Minniti, D., Lucas, P. W., *et al.* 2011, *Carnegie Obs. Conf. Ser.*, 5, 145
Catelan, M., Minniti, D., Lucas, P. W., *et al.* 2013, in: K. Kinemuchi, H. A. Smith & N. De Lee (eds.), *40 Years of Variable Stars: A Celebration of Contributions by Horace A. Smith*, p. 139
Minniti, D., Lucas, P. W., Emerson, J. P., *et al.* 2010, *New Astron.*, 15, 433
Saito, R. K., Hempel, M., Minniti, D., *et al.* 2012, *A&A*, 537, A107