# Multiperiodicity as a tool to investigate stellar physics.

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December 2018

**Abstract**

Our main interest are periodic variable stars and giant planet transit that will be discovered by LSST and in their use as standard candles, tracers of stellar populations and probe of planet formation. Since space photometry revealed that a significant fraction of the variables display secondary modulations on a timescale that is significantly longer than main oscillations we are also interested in the multi-periodicity with the final aim of monitoring and interpreting, with the use of stellar models, still little known phenomena such as the Blazko effect on light curves of RR Lyrae and the secondary periodicity of Long Period Variables. Therefore, we can use multiperiodicity in classical pulsators as a multi-object task to refine both the distance scale and the stellar physics.

## 1 Quintuplet Information 2018

1)Paolo Ventura (PI)– Staff at INAF-Osservatorio Astronomico di Roma
2)Marcella Di Criscienzo – Staff at INAF-Osservatorio Astronomico di Roma
3)Ester Marini – PhD student at University "Roma Tre"
4)Francesco Borsa – Postdoc at INAF-Osservatorio di Brera

## 2 Quintuplet Information 2019

1)Marcella Di Criscienzo (PI) –Reasercher at INAF-Osservatorio Astronomico di Roma
2)Paolo Ventura – Associate Professor at INAF-Osservatorio Astronomico di Roma
3)Ester Marini – PhD student at University "Roma Tre"
4)Francesco Borsa – Postdoc at INAF-Osservatorio di Brera
5)Ennio Poretti – Staff at INAF-Osservatorio di Brera

## 3 Scientific Collaborations

*What are the Science Collaborations and/or the Task Forces you joined during the last year?*

1. TVS;
2. MWLV;
3. Call for White Papers on LSST Cadence Optimization within the Task Forces organized by 1)Olsen, 2)Olsen/Szkody, 3)Musella/Clementini;
4. MAF implementation.

# 4 Scientific Activity

During **this first**[1] **year** of activity we worked in synergy with two other working groups of LSST-Italia that deal with stellar variability: 1)The Gaia-LSST synergy: from pulsating stars and star formation history to WD planets (PI Clementini ) and 2)RR Lyrae, Cepheids and LBVs to constrain theory using LSST observations (PI Musella). This synergy was recently consolidated with the writing of a white paper for the LSST cadence called "The Gaia-LSST Synergy: resolved stellar populations in selected Local Group stellar systems" where we propose a combination of the Wide-Fast-Deep survey and a mini-survey (or alternatively a modified WFD with a rolling cadence that doubles the number of visits in the first two years), in order to study the stellar variability of in/around six Local Group stellar systems (see Table 1) of different morphological type that are located from 30 to 400 kpc in distance from us.
In particular Marcella Di Criscienzo, Ester Marini and Paolo Ventura have dealt with the selection of the fields around the selected fields (see Table 1) and the computation of the recovery fraction of RR lyrae and Delta Scuti stars at the distance of that stellar system .
Furthermore, thanks to a collaboration born during the attended LSST hackaton@Flatiron Institute of New York Marcella Di Criscienzo participated, as a TVS representative, in a task force called "A big sky appraoch to cadence diplomcy" that had the purpose to find a new and original compromise between area, depht and temporal coverage of the main survey with the aim of alleviate many of the current concerns of Science Collaborations providing *A paceful solutions to cadence war*. For simplicity, we explored trades between the area of the LSST survey vs. the number of 30s visits per field (and hence its depth), leaving aside the question of the temporal cadence. For this purpose we have developed a simple Python tool, LynneSim, to help evaluate the potential for these trades. This tool, available for all to use in the LSST Science Collaborations' fork of the survey strategy white paper repository, is illustrated in example Jupyter notebooks here and here, and is scriptable. Our proposed solution define a new survey by avoiding the Galactic plane ($|b| > 15$) while extending symmetrically north and south far enough to meet the LSST SRD requirement of 18,000 deg$^2$, which results in a WFD footprint that covers $-72.25 < \mathrm{Dec} < +12.4$ (see Figure 1). We have assigned 825 visits per field to WFD, meeting the LSST SRD requirement of 825 median visits per field, and distributed the remaining visits to the non-WFD Big Sky fields. These non-WFD fields then received $\sim 250$ visits each, or 30% of the WFD visits, which is larger than the current baseline strategy for most parts of the sky. One of the benefits of this solution is the inclusion of Magellanic Clouds and their extended periphery in WFD survey increasing the discovery of its tidal debris, satellite debris and variable stars. In collaboration with Knut Olson and Paul Szkody we have proposed a combination of this modifed WFD survey, a mini-survey of the South Celestial Pole and a Deep Drilling style survey to produce a 3-D map of the Magellanic System and to provide a detailed census of the transient and variable population in the Clouds. The details was written in the white paper called "Mapping the Periphery and Variability of the Magellanic Clouds" and attached at this document in which Marcella Di Criscienzo, Paolo Ventura and Francesco Borsa collaborated in defining the right strategy to be adopted on MC main body fields.

Concluding this group is in good health , despite having joined the LSST collaboration late. Their members have worked actively as documented by three submitted white papers and have recently started important collaborations. We wish the group members to be confirmed for the next year, following the directions given in the section 2. We will work, among other things, on the definition of further scientific cases (LPV, planets) that will included in LSST TVS RoadMap Document (whose Draft in still progress) and on the development of a new simulation tool for transient observations of planets.

[1]This is the 16th group excluded from the first year of LSST-Italia

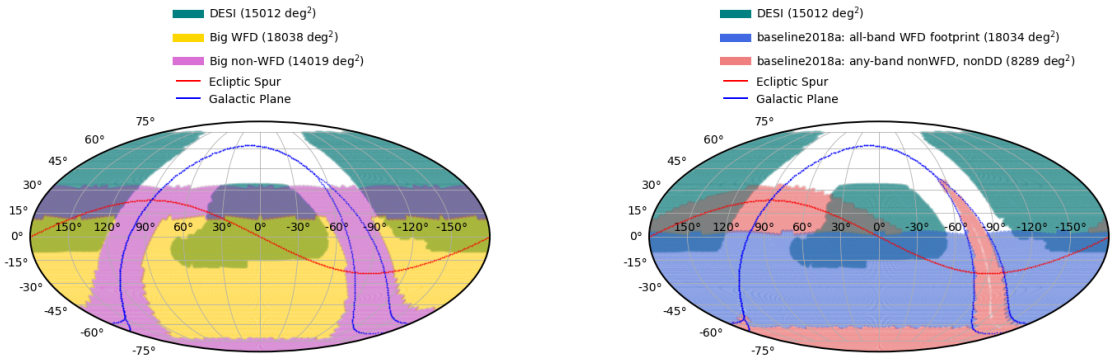


Figure 1: *Left*:The proposed Big Sky footprint of "A Big Sky Approach to Cadence Diplomacy" task force : yellow fields denote our recommended expanded WFD footprint while the purple fields represent the mini-surveys in the extended footprint. *Right:* Footprint from baseline2018a for WFD (blue) and all the mini-surveys aside from the DDFs (coral red).

Table 1: Information on the selected stellar systems during the Task Force "The Gaia-LSST Synergy: resolved stellar populations in selected Local Group stellar systems". In particular, in the last three columns the number of visits in the g, r and i bands (Ng, Nr and Ni) are reported , planned by baseline2018a.db, in the first two years, for fields that include the center of these six systems. that will be doubled in the proposed Deep drilling type mini-survey

| Target | RA(J2000) | DEC(J2000) | $(m-M)_0$ | E(B-V) | Ng | Nr | Ni |
|---|---|---|---|---|---|---|---|
| M54/Sagittarius | $18^h55^m03.3^s$ | $-30°28^m43.0^s$ | 17.13 | 0.15 | 13 | 33 | 37 |
| Sculptor | $01^h00^m09.35^s$ | $-33°42^m32.5^s$ | 19.57 | 0.016 | 26 | 44 | 47 |
| Carina | $06^h41^m36.7^s$ | $-50°57^m58.0^s$ | 20.08 | 0.05 | 14 | 33 | 31 |
| Fornax | $02^h39^m59.33^s$ | $-34°26^m57.1^s$ | 20.70 | 0.02 | 28 | 50 | 56 |
| Phoenix | $01^h51^m06.3^s$ | $-44°26^m41^s$ | 23.10 | 0.014 | 14 | 23 | 24 |
| Antlia 2 | $9^h35^m32.64^s$ | $-36°46^m02.28^s$ | 20.56 | 0.19 | 26 | 57 | 58 |

# 5 Scientific and technical deliverables

**The Gaia-LSST Synergy: resolved stellar populations in selected Local Group stellar systems**
*G. Clementini, I. Musella, M. Cignoni,F. Cusano,* **M. Di Criscienzo**, *M. Fabrizio, A. Garofalo, M. Limongi, M. Marconi,***E. Marini**, *A. Marino , P. Marrese, R. Molinaro2, M.I. Moretti, T. Muraveva, V. Ripepi, G. Somma ,* **P. Ventura**.

**A Big Sky Approach to Cadence Diplomacy**
*Knut Olsen (SMWLV),***Marcella Di Criscienzo (SMWLV, TVS)**, *R. Lynne Jones (Solar System), Megan E. Schwamb (Solar System), Hsing Wen "Edward" Lin (Solar System), Humna Awan (DESC), Phil Marshall (DESC, Strong Lensing), Eric Gawiser (Galaxies, DESC), Adam Bolton, Daniel Eisenstein*

**Mapping the Periphery and Variability of the Magellanic Clouds**
*Knut Olsen, Paula Szkody, Maria-Rosa Cioni,* **Marcella Di Criscienzo**, *Ilaria Musella, Vincenzo Ripepi,* **Francesco Borsa**, *Marcella Marconi, Léo Girardi, Giada Pastorelli, Michele Trabucchi,* **Paolo Ventura**, *Marc Moniez*

**MAF contribution**
Some of us have worked with MAF developers such as Lynne Jones, Peter Yoachim and Keaton Bell to build and update some variability metrics.

# 6 Other information

*Any other information concerning your scientific activity (meetings, zoom/skype).*

Marcella Di Criscienzo participated in September 2018 at the LSST Hackathon@Flatiron Institute ofNew York organized and funded by the Simon Fundation and in the last months she spends few days to the INAF Osservatorio di Napoli to collaborate with the Musella / Marconi group and with Massimo Dall'Ora , chair of the TVS subgroup Pulsating stars
Unfortunately for overlapping with other commitments, no members of this group were able to attend the LSST Meetings of Lyon in june, Tucson in August and Palermo in October.