WHAT WAS THAT? – PLANNING ESO FOLLOW UP FOR TRANSIENTS, VARIABLES, AND SOLAR SYSTEM OBJECTS IN THE ERA OF LSST

22 - 26 January 2024

ESO Workshop, Garching

Table of contents

Program

Day 0 - Monday, 22nd January

17:30 - 19:30 Registration and beer & brezen reception

Day 1 - Tuesday, 23rd January

08:30 - Registration

09:00 - Welcome & Introduction

SESSION 1 - LSST OVERVIEW

09:15 - Invited - ***Status update for the Rubin Observatory Construction Project*** - **Zeljko Ivezic**, University of Washington

09:50 - Invited - ***The Vera C. Rubin Observatory International In-kind Program*** - **Aprajita Verma**, University of Oxford

10:15 - Contributed - ***Lightning talks***, block 1 (5 talks x 2 min. each)

10:30 - Coffee break

SESSION 2 - ESO OVERVIEW

11:00 - Invited - ***ESO facilities in the next decade*** - **Bruno Leibundgut**, **Ferdinando Patat and Marina Rejkuba**, ESO

12:15 - Contributed - ***Lightning talks***, block 2 (5 talks x 2 min. each)

12:30 - Lunch

SESSION 3 - EXTRAGALACTIC SCIENCE

14:00 - Invited - ***Extreme AGN Variability in LSST and Synergies with ESO facilities*** - **Matthew Temple**, Universidad Diego Portales

14:25 - Invited - ***Supernova and extragalactic transients in the LSST era*** - **Kate Maguire**, Trinity College Dublin

14:50 - Contributed - ***Lightning talks***, block 3 (15 talks x 2 min. each)

15:30 - Coffee break

SESSION 4 - GALACTIC SCIENCE

16:00 - Invited - ***Variable Stars in the era of Rubin's LSST*** - **Richard Anderson**, EPFL

16:25 - Invited - ***Radially Pulsating Stars: Insights from Theoretical Framework in the Gaia and Rubin-LSST Era*** - **Giulia De Somma**, INAF

16:50 - Invited - ***Population studies of accreting white dwarfs with the Vera Rubin Observatory and ESO*** - **Anna Francesca Pala**, European Space Agency

17:15 - Contributed - ***Lightning talks***, block 4 (5 talks x 2 min. each)

Day 2 - Wednesday, 24th January

SESSION 5 - LSST BROKERS AND SYSTEMS

09:00 - Invited - ***The ALeRCE astronomical alert broker*** - **Francisco Forster**, Universidad de Chile

09:15 - Invited - ***AMPEL: LSST alerts, photometric classifications and how to build your own real-time workflow*** - **Jakob Nordin**, Humboldt-Universität zu Berlin

09:30 - Invited - ***The ANTARES Time-Domain Event Broker*** - **Gautham Narayan**, University of Illinois, Urbana-Champaign

09:45 - Invited - ***BABAMUL - what do brokers dream of?*** - **Matthew J. Graham***, Caltech

10:00 - Invited - ***A community driven broker for the Rubin era*** - **Emille Ishida**, Laboratoire de Physique de Clermont

10:15 - Invited - ***The UK Alert Broker*** - **Roy Williams**, University of Edinburgh

10:30 - Coffee Break

11:00 - Invited - ***The Pitt-Google Community Alert Broker*** - **Michael Wood-Vasey**, University of Pittsburgh

11:15 - Invited - ***TOMs and Telescope Networks for Time-Domain and Transient Targeting*** - **Tim Lister**, Las Cumbres Observatory

11:30 - Invited - ***An observer's perspective on the Astronomical Event Observatory Network (AEON)*** - **Carrie Holt**, Las Cumbres Observatory

11:45 - Invited - ***NOIRLab's Time Domain Capabilities*** - **Bryan Miller**, Gemini Observatory/NSF's NOIRLab

12:05 - Invited - ***Power of many - BHTOM telescope network for time-domain astronomy*** - **Lukasz Wyrzykowski**, Warsaw University Astronomical Observatory

12:30 - Lunch

SESSION 6 - SOLAR SYSTEM AND YSO SCIENCE

14:00 - Invited - ***Small Bodies, Big Survey: Solar System Science with LSST*** - **Max Mahlke**, Institut d'Astrophysique Spatiale

14:25 - Invited - ***LSST's potential to study transient phenomena in small solar system bodies*** - **Jessica Agarwal**, TU Braunschweig

14:50 - Invited - ***The physics of young stellar objects across the wavelength and time domains*** - **Laura Venuti***, SETI Institute

15:15 - Contributed - ***Lightning talks***, block 5 (5 talks x 2 min. each)

15:30 - Coffee break

SESSION 7 - DEI

16:00 - Invited - ***Embedding DEI principles in ESO's mission*** - **Francesca Primas**, ESO

16:25 - Invited - ***DEI @ NOIRLab and Rubin Operations*** - **Alysha Shugart**, Rubin Observatory / NOIRLab

17:00 - Contributed - ***Lightning talks***, block 6 (10 talks x 2 min. each)

19:30 - Social dinner at Der Pschorr - Viktualienmarkt 15 - 80331 Munich

Day 4 - Thursday, 25th January

SESSION 8 - FUTURE FACILITIES & PROJECTS

09:00 - Invited - ***The new SOXS instrument for the ESO NTT: overview and status of the project*** - **Paolo D'Avanzo**, INAF - Brera Astronomical Observatory

09:25 - Invited - ***The 4MOST Time Domain Extragalactic Survey (TiDES)*** - **Isobel Hook**, Lancaster University

09:50 - Invited - ***The Wide-field Spectroscopic Telescope (WST) and its synergies with Rubin/LSST*** - **Richard Anderson**, EPFL

10:15 - Contributed - ***Lightning talks***, block 7 (5 talks x 2 min. each)

10:30 Coffee break

SESSION 9 - LESSONS FROM PAST SURVEYS

11:00 - Invited - ***Gaia Photometric Science Alerts: current status and cataclysmic variable discovery*** - *Elmé Breedt*, Institute of Astronomy, University of Cambridge

11:25 - Invited - ***Lessons from ePESSTO+ for coordinated LSST follow-up*** - **Janet Ting-Wan Chen**, Institute of Astronomy, National Central University

11:50 - Contributed - ***Lightning talks***, block 8 (5 talks x 2 min. each)

12:15 - Preparation for breakout sessions, information about rooms for afternoon, etc. SOC/LOC

12:30 - Lunch

14:00 - ***Breakout sessions*** - discussion on ways to proceed with coordinated projects & proposals

15:30 - Coffee break

16:00 - ***Breakout sessions*** - discussion on ways to proceed with coordinated projects & proposals

Day 5 - Friday, 26th January

SESSION 10 - VARIOUS CONTRIBUTED TALKS

09:00 - Contributed - ***SNAD: enabling discovery in the era of big data*** - **Maria Pruzhinskaya**, Laboratoire de Physique de Clermont

09:15 - Contributed - ***Transient Classifiers for Fink: glimpses from the ELAsTICC data challenge*** - **Etienne Russeil**, Laboratoire de Physique de Clermont

09:30 - Contributed - ***An Advanced Platform for Real-Time Multi-Messenger Astrophysics*** - **Fabian Schussler**, IRFU, CEA Paris-Saclay

09:45 - Contributed - ***Science with the Danish 1.54m telescope in the era of LSST*** - **Christa Gall**, Niels Bohr Institute, UCPH

10:00 - Contributed - ***The Gravitational-wave Optical Transient Observer (GOTO)*** - **Thomas Killestein**, University of Turku

10:15 - Contributed - ***Bridging the Spectrum: from Optical to Radio Transients*** - **Iris de Ruiter***, Anton Pannekoek Institute

10:30 - Coffee Break

11:00 - ***Summaries of breakout discussions and conclusions*** of meeting Discussion leads and SOC

12:00 - End of workshop

About the workshop

The goal of this meeting is to encourage coordination in the communities who study the variable, transient and moving objects that the Vera C Rubin observatory's LSST will discover vast numbers of, to figure out how best ESO's facilities can provide the necessary follow up.

We will introduce the LSST and its public alerts (and 'brokers' and related systems for filtering these) to a wider ESO audience, discuss how previous surveys of transients (e.g. PESSTO) have operated and what models are best for the LSST era, and provide an opportunity for the communities of researchers in these topics to come together to plan coordinated efforts. Coordination will be key to maximising the science that can come from combining LSST discoveries and the wide variety of detailed observations possible with ESO facilities. The purpose of this meeting is to provide a platform to explore collaboration and coordinated ESO programmes in the LSST era.

Conference topics:

- Introductions to LSST, its alert brokers, and ESO facilities in the next decade
- Results and lessons learned from previous surveys (e.g. Gaia alerts, ZTF, PESSTO)
- The transient sky (e.g. CVs, SNe, etc.)
- The variable sky (e.g. variable stars, AGN, Microlensing, etc.)
- The moving sky (e.g. Solar system discoveries and transient phenomena)

Abstracts

Invited Talks

Agarwal, Jessica (TU Braunschweig, Braunschweig, Germany), In-person

LSST's potential to study transient phenomena in small solar system bodies

Transient phenomena in this context are those that evolve on short time scales and are often, but not necessarily, unpredicted.

This talk will present some known categories of transient phenomena and the expected contribution of LSST to advance our understanding of them.

LSST will be particularly sensitive to changes of an object's integrated brightness, where a suddenly increased brightness can even be the cause of discovery.

A typical cause of brightening on short timescales is the emission of dust due to violent phenomena like impacts or landslides, potentially uncovering buried volatiles whose sublimation would entrail additional dust. In comets, sudden brightness changes are summarily called outbursts. Dust emitting asteroids are called "active asteroids". The talk will summarise the processes leading to asteroid activity and cometary outbursts, with a particular focus on the time evolution of the brightness.

The transient nature of other objects is related to their parabolic or hyperbolic orbits. They originate either from the Oort Cloud ("Long Period Comets", LPCs) or from other star systems ("Interstellar Objects", ISOs). LSST is expected to discover such objects further out than previous surveys, where activity is driven by species more volatile than water ice. The talk will describe the currently known population of LPCs and ISOs, their discovery circumstances, and the expected contribution of LSST to new discoveries and their follow-up monitoring.

Anderson, Richard (EPFL, Lausanne, Switzerland), In-person

The Wide-field Spectroscopic Telescope (WST) and its synergies with Rubin/LSST

WST will be the crucial spectroscopic complement to Rubin's photometric LSST. WST is an innovative 10-m class wide-field telescope that allows simultaneous operation of a multi-object spectrograph (MOS) fed by ~20,000 low-resolution and ~2,000 high-resolution fibers across a very large field-of-view (3+ sq. degree) and an unprecedented (9 sq. arcmin) panoramic integral field spectrograph (IFS). Featuring both higher resolution and larger collecting area than 4MOST, a factor of several increase in fiber number, and an IFS 9 times the area of MUSE, WST will lead to breakthrough results across most areas of astrophysics, including the physics of the dark Universe, the first stars and galaxies,

cosmic reionisation, the baryon cycle, the stellar populations of the Local Group, and the characterization of exoplanet host stars.

Crucially, a time-domain mindset is built into WST from the start, meaning that transient and time-variable phenomena are considered on par with cosmological, extragalactic, and Galactic science cases. In particular, WST will target synergies with multi-messenger astrophysics and be strongly influenced by time-domain surveys carried out in the meantime, notably ESA's Gaia mission and Rubin's LSST.

Here, I will give an overview of WST as a facility and the current priorities identified by the time-domain working group. These include telescope-level ToOs to identify and characterize the electromagnetic counterparts of merging neutron stars, fiber-level ToOs for transient follow-up, AGN reverberation mapping, synoptic studies of stellar variability, and Solar system science, among others. The ability to issue alerts will render WST a veritable time-domain machine with crucial abilities in the Rubin era and beyond.

Anderson, Richard (EPFL, Lausanne, Switzerland), In-person

Variable Stars in the era of Rubin's LSST

Variable star research is about to undergo a revolution driven by large time-resolved imaging surveys such as ESA's Gaia mission and Rubin/LSST. Gaia is expected to increase the number of variable stars from 10 million to more than 100 million by the end of 2025, and Rubin/LSST will further dwarf this number by providing access to the faint variable sky and surveying the variable star populations at distances of up to several Mpc.

In this era of low-frame rate color video of the sky, the variability of all stars on a plethora of time scales will be available, breaking down barriers among disciplines. For example, the saying that “all stars are variable on some time scale” may be expanded by “at some limit of photometric precision.”

Starting with the Variability Tree, I will describe different classes of variable stars, their time scales of variability, amplitudes, as well as some potential insights to be gained from investigating different types of variability. Given the unprecedented volume and homogeneity of the incoming data, it is highly likely that the incompleteness of our understanding of stellar variability will be ruthlessly exposed. To maximize the harvest for variable stars, machine learning methods for variable star classification will be indispensable. However, observational follow-up, notably using spectrographs and multi-wavelength photometry will be crucial to ensure correct classification, and facilities capable of very high spatial resolution, such as the ELT, will be crucial to accurately measuring the properties of very distant variable stars.

Breedt, Elmé (Institute of Astronomy, University of Cambridge, Cambridge, UK), In-person

Gaia Photometric Science Alerts: current status and cataclysmic variable discovery

The Gaia Alerts system has been running routinely and reliably since January 2016, currently publishing >12 transients per day, using well-defined selection criteria. I'll describe some of the challenges we face in searching through half a billion CCD measurements every day to identify and publish Gaia's transient events. I'll highlight cataclysmic variable discovery with Gaia and other wide area photometric surveys and discuss the advantages and disadvantages of transient discovery for these systems. I'll show what we can learn about the CV population from these faint systems. At the moment, Gaia Alerts is the only transient survey which provides all-sky coverage at high spatial resolution, and the data are public immediately after discovery.

Chen, Janet Ting-Wan (Institute of Astronomy, National Central University, Taoyuan City, Taiwan), In-person

Lessons from ePESSTO+ for coordinated LSST follow-up

ESO's expertise in transient astronomy drives collaborative efforts to maximise the value of sky surveys. As LSST comes online, it promises a new level of data streaming and opportunities for unexpected discoveries. However, these advancements also bring new challenges in terms of collaboration and the development of efficient follow up observations. The PESSTO programme has achieved a decade of success, involving 270 scientists in this collaboration. Since 2019, I have co-led the ePESSTO+ phase. In this presentation, I will summarise the scientific outcomes of ePESSTO+, highlighting interesting objects. To date, PESSTO has classified 3616 transients, releasing alerts and making data available to the public within 24 hours of observations. PESSTO has also followed up on 1144 transients. The collaboration has resulted in more than 150 publications. I will also discuss our working structure, data release process, and how we integrate researchers at different career levels to foster a collaborative and efficient work environment. These structures could serve as a model for future LSST collaborations.

D'Avanzo, Paolo (INAF - Brera Astronomical Observatory, Merate, Italy), In-person

The new SOXS instrument for the ESO NTT: overview and status of the project

SOXS (Son Of X-Shooter) will be a unique spectroscopic facility built by an international consortium for the ESO-NTT 3.6-m telescope in La Silla (Chile). The design foresees a single-object, high-efficiency spectrograph with a resolution-slit product of ~4,500, capable of simultaneously observing the complete spectral range 350-2000 nm with a good sensitivity and with imaging capabilities in the visible band (ugrizY). It is designed to observe all kinds of transients and variable sources discovered by different surveys with a highly flexible schedule maintained by the consortium, based on the Target of Opportunity concept. SOXS is going to be a fundamental spectroscopic partner for any kind of imaging survey, becoming one of the premier transient follow-up instruments in the Southern hemisphere.

De Somma, Giulia (INAF-Astronomical Observatory of Capodimonte, Naples, Italy), In-person

Radially Pulsating Stars: Insights from Theoretical Framework in the Gaia and Rubin-LSST Era

Pulsating stars, renowned as accurate primary distance indicators, play a crucial role in calibrating the cosmic distance ladder and serve as reliable tracers of stellar populations.

In this presentation, I provide a concise overview of the evolutionary status of the most relevant radially pulsating stars.

I present recent results for Classical Cepheids. employing the Stellingwerf hydrodynamical code to construct an updated set of nonlinear pulsation models. These models accurately predict various observable quantities, including instability strips, multifilter light curves, mean magnitudes, and colors.

Building on these predictions, I establish metal-dependent period-luminosity-color and period-Wesenheit (PWZ) relations in the Rubin-LSST and Gaia filters. Integrating this pulsational framework with updated stellar evolutionary models from the BASTI database, I derive precise metal-dependent Period-Age and Period-Age-Color (PACZ) relationships in the Rubin-LSST and Gaia filters.

To validate this framework, I apply PWZ and PACZ relations to a Gaia Early Data Release 3 Galactic Cepheid sample. The theoretical parallaxes obtained from the PWZ relations are compared with Gaia's astrometric results, and the application of PACZ relations enables the constraint of the Cepheid age distribution.

These findings are discussed in the context of the forthcoming SPECTRUM project, which aims to combine pulsation and evolutionary codes for the first time.

Forster, Francisco (Universidad de Chile, Santiago, Chile), In-person

The ALeRCE astronomical alert broker

In order to take advantage of a new generation of large aperture and large field of view telescopes, notably the Vera C. Rubin Observatory, a new time domain ecosystem is developing. Among the tools required are fast machine learning aided discovery and classification algorithms, interoperable tools to allow for an effective communication with the community and follow-up telescopes, and new models and tools to extract the most physical knowledge from these observations. In this Talk I will review the challenges and progress of building the Automatic Learning for the Rapid Classification of Events (ALeRCE) astronomical alert broker. ALeRCE (http://alerce.science/) is a broker that annotates, classifies and provides access to a living database of variable astronomical objects since 2019. ALeRCE is focused around three scientific cases: transients, variable stars and active galactic nuclei, and has become the 3rd group to report most transient candidates to the Transient Name Server. I will also discuss some of the results based on the real-time

ingestion and classification of the Zwicky Transient Facility (ZTF) alert stream, from the Asteroid Terrestrial-impact Last Alert System (ATLAS) telescopes, and the classification of simulated data for the Vera C. Rubin Observatory in the context of the ELAsTiCC challenge.

Graham, Matthew J. (Caltech, Pasadena, USA), Remote

BABAMUL - what do brokers dream of?

With over 700 million alerts over the past six years, ZTF has been foundational in defining the landscape for real-time transient astronomy, as well as providing significant contributions to more general time domain astronomy. As we transition into the LSST era, we enter a new regime where this represents less than three months of data and this provides new challenges. In this talk, I will review the state-of-the-art within ZTF for managing alerts and follow-up observations and also consider what we should really be doing to best serve the community.

Holt, Carrie (Las Cumbres Observatory, Goelta, USA), In-person

An observer's perspective on the Astronomical Event Observatory Network (AEON)

The need for rapid response systems and efficient use of finite telescope resources is crucial in the LSST era. The 4.1-m Southern Astrophysical Research (SOAR) telescope in Cerro Pachón has incorporated queued observing via the Astronomical Event Observatory Network (AEON) since 2019. Interest in AEON observing with SOAR has continued to increase, as have the program's capabilities. In 2023B AEON was scheduled for 44 nights for 15 regular programs and 10 Target of Opportunity programs. The instruments available include the Goodman High Throughput Spectrograph and the newly added TripleSpec 4.1 spectrograph. SOAR has recently implemented narrow-band comet filters in AEON mode as well.

Since February 2021, we have used AEON mode with SOAR to monitor 8 newly discovered, distant dynamically new comets ~monthly over more than 100 hours total without requiring multiple full or half nights. In most cases, we observe a newly discovered target within a few days of the discovery announcement, and each observation is less than an hour. We will describe our experience using AEON, which we have refined over the past three years. Topics will include proposal writing, the scheduling interface, real-time data access, reduction, and the final product. There is also the potential for implementing TOM systems via an API. Finally, we will discuss the future of AEON as a tool for LSST follow-up, including the addition of the 4-m Blanco telescope.

Hook, Isobel (Lancaster University, Lancaster, UK), In-person

The 4MOST Time Domain Extragalactic Survey (TiDES)

I will present an overview of the Time Domain Extragalactic Survey (TiDES), which will be carried out using the 4MOST instrument. Over the course of the 5-year survey, TiDES will obtain follow-up spectra of about 35000 “live” transients and 50000 host galaxies (although these estimates depend on the survey strategy, which is still under development). I will describe the selection of transient sources and host galaxies from the Rubin Observatory's Legacy Survey of Space and Time (LSST) and other photometric surveys. I will then describe the expected output spectroscopic data from TiDES and some of the planned scientific uses of the data, including SN Ia cosmology and transient demographics.

Ishida, Emille (CNRS/LPC-Clermont, Aubierre, France), In-person

A community driven broker for the Rubin era

The next generation experiments such as the Vera Rubin Observatory Legacy Survey of Space and Time (LSST) will provide a rich source of information for multi-messenger astronomy tasks. To fully harness the power of these surveys, we require infrastructure and analysis methods capable of dealing with large streams and tailor subsets of data for specific science cases. In this Talk I will present Fink, an astronomy broker specifically designed for LSST. Fink is based on high-end technology and designed for fast, efficient and customizable analysis of big data streams. I will highlight the state-of-the-art machine learning techniques used to generate early classification scores for a variety of time-domain phenomena, including supernovae, kilonovae, AGNs, young stellar objects, among many others. I will also describe how the user can develop tailored filters and science modules for other applications. In combination with efforts to engage local communities in Australia and Brazil, this will give a broad view of the broker goals and how users can be active actors in the customization of their own sub-streams for each individual science cases.

Ivezic, Zeljko (University of Washington, Seattle, USA), In-person

Status update for the Rubin Observatory Construction Project

The construction of Vera C. Rubin Observatory is approaching its end. The last major piece of equipment, the LSST Camera, will be be shipped to Chile in early 2024. The start of the Legacy Survey of Space and Time is anticipated for 2025. I will provide a brief construction status update and a summary of data release plans and anticipated early science programs.

Leibundgut, Bruno (ESO, Garching, Germany), Talk, In-person

ESO facilities in the next decade

We will present the observing capabilities and the changes in the time allocation process ESO foresees to have in place during the LSST era.

Lister, Tim (LCO, Santa Barbara, USA), In-person

TOMs and Telescope Networks for Time-Domain and Transient Targeting

The ability to synthesize discovery data from multiple sources, and respond with complementary follow-up observations in real-time, is critical to many science goals in Multi-Messenger and Time-Domain Astrophysics. In an era of large increases in the number of targets both overall and for a particular science area of interest, the need for Target and Observation Manager (TOM) systems to coordinate follow-up and networks of telescopes such as AEON (Astronomical Event Observatory Network) that can rapidly respond to follow and characterize new discoveries becomes vital.

The TOM Toolkit provides easy-to-use software tools to enable observers to manage discoveries and data in real-time, filter and identify their targets of interest and obtain the observations necessary for characterization. We provide an overview of the TOM Toolkit, including recent upgrades to the TOM Toolkit to support detections from Gravitational Wave and Neutrino detectors, observations on the Swift satellite as well as support for discovery follow-up in the LSST era. With the large volume of targets, efficient use of a finite set of telescope resources for follow-up is essential. AEON has developed tools to enable observatories to be more responsive to time-domain observations, while retaining complete control over their operations and time allocation. These applications include an online portal to submit observation requests and software to help operators to manage and schedule the requested observations.

Maguire, Kate (Trinity College Dublin, Dublin, Ireland), In-person

Supernova and extragalactic transients in the LSST era

Supernovae and extragalactic transients are the sometimes incredibly luminous, and sometimes not so luminous, deaths of stars that play a vital role in chemical enrichment, galaxy feedback mechanisms, cosmological measurements, and our understanding of stellar evolution. In this talk, I will outline the state-of-the-art in the field of their discovery, follow-up and link to theoretical explosion models. I will discuss the game-changing nature of LSST for the field and the potential for major breakthroughs in our understanding of stellar astrophysics and cosmology, as well as some of the challenges and steps towards solutions that will we need to fully exploit this incredibly rich dataset.

Mahlke, Max (Institut d'Astrophysique Spatiale, Paris, France), In-person

Small Bodies, Big Survey: Solar System Science with LSST

The history of the Solar System is imprinted in its minor bodies. As remnants of early planetesimals, their dynamical and compositional distributions today allow us to infer on the conditions of our planetary system in its initial stage and its subsequent dynamical evolution.

Previous large sky surveys have contributed significantly to the discovery and description of the populations of minor bodies. The Legacy Survey of Space and Time will make no difference here. On the contrary, its vast amount of data and its depth promise to reveal dynamical and compositional properties of minor bodies in incredible detail if the challenges that go along with this promise are met. In this talk, I will provide an overview of different fields of minor body research, how LSST observations will contribute to their advancement, and the challenges we may anticipate.

Miller, Bryan (Gemini Observatory/NSF's NOIRLab, La Serena, Chile, In-person

NOIRLab's Time Domain Capabilities

The era of large transient surveys and multi-messenger astronomy provides many exciting opportunities for new discoveries. However, the volume of alerts makes software automation imperative for object classification, prioritization, scheduling, and data reduction so that the community can get the most science from the new data. Therefore, the NSF's National OIR Astronomy Research Laboratory (NOIRLab: Rubin, Gemini, SOAR, CTIO, KPNO, and the Community Science and Data Center) aims to provide a full set of time-domain capabilities. Rubin Observatory's LSST will be the preeminent time-domain survey in the next decade. The ANTARES broker collects and classifies events, from ZTF currently and LSST in the future. NOIRLab has teamed up with the Las Cumbres Observatory to develop tools for automating transient follow-up and to incorporate the participating telescopes into the Astronomical Event Observatory Network (AEON). SOAR now has an "AEON", or queue, mode that makes use of the Las Cumbres scheduler and the 4-m Blanco telescope at CTIO will be added soon. Gemini is building new instruments, working on significant software upgrades to improve usability, implementing an automatic scheduler, and adding Gemini Observatory Archive connections and data reduction capabilities to time-domain workflows. Some data are now being reduced in real-time and are distributed via the NOIRLab and Gemini science archives. This presentation will describe these capabilities and future plans.

Narayan, Gautham (University of Illinois, Urbana-Champaign, Urbana, USA), In-person

The ANTARES Time-Domain Event Broker

The astronomical community is in the midst of a revolution in Time-Domain Astronomy. The age of serendipitous discoveries of a few objects that were followed by a handful of astronomers is well in the past. Wide-field telescopes with large-format CCDs have enabled time-domain surveys that cover hundreds to thousands of square degrees every

night. The Zwicky Transient Facility (ZTF) produces several hundred thousand public time-domain alerts each night, while the Rubin Observatory Legacy Survey of Space and Time (LSST) will conduct a wide, fast, and deep survey of the southern sky that should generate several million alerts per night. This scale of alerts will require automated tools to filter the stream so that astronomers can find the specific objects of interest to them. The ANTARES broker at NSF's NOIRLab is such a tool, processing real-time streams, associating, characterizing, categorizing and disseminating these alerts to the scientific community. I will describe the current status of the broker, some of the algorithms we have developed to filter alerts, and how it integrates with the LSST DESC infrastructure.

Nordin, Jakob (Humboldt-Universität zu Berlin, Berlin, Germany), In-person

AMPEL: LSST alerts, photometric classifications and how to build your own real-time workflow

Future astronomical time-domain surveys, like LSST, will produce large streams of real-time observations, each potentially a key link to new physical insight but where we have nowhere near the capacity to follow all. Automated and typically machine-learning based methods will be needed to parse these streams. This is especially true for multi-messenger astronomy, where multiple heterogeneous streams are to be combined.

AMPEL is a framework for streaming data analysis, written in Python, and with a focus on time-domain astronomy. It enables users to build analyses out of hierarchies of single-purpose units and coordinates the execution of these units on a stream of data. A public, live AMPEL instance hosted at DESY Zeuthen will parse the LSST alert streams.

I will here discuss how users will be able to access real-time data and classifications, as well as how science workflows tuned for specific science goals can be created and directly applied to alerts from the Vera Rubin Observatory. Finally, I will comment on the outlook for photometric classification based on the ongoing ELAsTiCC simulation.

Pala, Anna Francesca (European Space Agency, Madrid, Spain), In-person

Population studies of accreting white dwarfs with the Vera Rubin Observatory and ESO

Accreting white dwarfs are compact interacting binaries in which a white dwarf is accreting matter from a companion star via Roche lobe overflow. Their large numbers, proximity, and brightness make these systems an ideal laboratory for refining the models of binary evolution, and unraveling the pathways to Type Ia Supernova (SN Ia) explosions.

The Vera Rubin Observatory will deliver a wealth of photometric data that will enables detailed and powerful statistical population studies across all areas of astrophysics. In particular, it will a game-changer for the study of accreting white dwarfs as it will allow the identification of thousands of these binaries.

In this talk, I will discuss the scientific implications of such discoveries and the fundamental role that the current and future ESO facilities will play in their follow-up observations, emphasising their importance for advancing our understanding of SN Ia progenitors and the mechanisms of compact binary formation and evolution.

Patat, Ferdinando (ESO, Garching, Germany), In-person

ESO facilities in the next decade

We will present the observing capabilities and the changes in the time allocation process ESO foresees to have in place during the LSST era.

Rejkuba, Marina (ESO , Garching, Germany), In-person

ESO facilities in the next decade

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Temple, Matthew (Universidad Diego Portales, Santiago, Chile), In-person

Extreme AGN Variability in LSST and Synergies with ESO facilities,

I will present an overview of AGN science in LSST, with a particular focus on AGN variability science and potential synergies with ESO follow-up facilities. Our understanding of AGN variability is continually increasing with data from ongoing surveys, but the Rubin Observatory will open a new discovery window in parameter space.

LSST will be able to identify extreme variability events in AGN, which could be driven by rapid changes in the SMBH accretion flow, changes in obscuration, jet activity, microlensing, or possibly even more exotic physics. This multiplicity of physical mechanisms means that changes in the LSST photometric time series will not always correlate with changes in the spectroscopic type classification. Timely spectroscopic and/or multiwavelength follow-up will be required to classify such phenomena, and subsequent monitoring will be crucially important to provide the observational foundation for physical interpretation. However, such objects will first need to be selected from the LSST data stream - all AGN are variable at some level and care will be needed to identify “extreme” variability events from the background defined by the rest of the AGN population.

Venuti, Laura (SETI Institute, Mountain View, USA), Remote

The physics of young stellar objects across the wavelength and time domains

Photometric variability is a defining feature of young stellar objects (YSOs), and it provides a unique observational tool to reconstruct the physical conditions at the stellar surface and in the inner circumstellar disk regions for large samples of young stars. YSO variability is a panchromatic phenomenon, with characteristic signatures from the ultraviolet to the infrared that reflect the dynamics and interplay of distinct physical processes, from stellar magnetic activity to mass accretion and star-inner disk interaction. Prominent flux changes are typically observed on YSOs on baselines of hours to weeks, which mirror the dynamical timescales of the inner disk. For some YSOs, known as eruptive variables, more intense flux variations have been identified on timescales of years to decades. While recent years have witnessed great advances in our description of young stellar variability, the targeted nature and non-uniformity of earlier campaigns, combined with the sparsity of multi-wavelength data, have hindered the possibility of achieving an unbiased census of YSO populations and their physical properties in different star formation environments and across all timescales of interest. In this Talk, I will review the current state of the art in the field, and discuss the potential of harvesting the distinctive imprints of YSO variability with Rubin LSST to build a first homogeneous, large-scale, multi-color, dynamic map of pre-main sequence populations in the southern sky.

Verma, Aprajita (University of Oxford, Oxford, UK)**,** In-person

The Vera C. Rubin Observatory International In-kind Program

The Rubin Observatory In-kind Program comprises over 150 diverse contributions from the international community spanning Telescope Time, Datasets, Data Access Centres and computing resources, Operations offsets and Software received by Science Collaborations and the Observatory. In this session, I will provide an overview of the contributions, with an emphasis on contributions from European programs. I will highlight the in-kind resources available to the wider Rubin community that are of particular relevance to this meeting.

Williams, Roy (University of Edinburgh, Edinburgh, UK)**,** In-person

The UK Alert Broker

Lasair is unique among the community brokers because its primary focus is not classification of active objects, but rather allowing users to build filters that select interesting alerts from the whole stream. Filters are defined by SQL-like language that acts on sky context, light-curve features, watchlists, sky area, and the classifications of other brokers. The system is extensible: users can build an annotator on an external system that can compute and classify, then push their results back to Lasair, for use by others in filtering.

Wood-Vasey, Michael (University of Pittsburgh, Pittsburgh, PA, United States), In-person

The Pitt-Google Community Alert Broker

The Pitt-Google Broker which is one of the LSST Community Alert Brokers that will distribute information about transient and variable events worldwide. Our broker is a modular cloud-native design that allows people to interact with and connect to at all levels. Ingesting, characterizing, classifying, and broadcasting events are all done through public Pub/Sub streams. Users can listen and connect to the system at any level. I will present our design, examples of adding classifiers, experience listening to the ZTF stream, and plans for the future.

Wyrzykowski, Lukasz (Warsaw University Astronomical Observatory, Warsaw, Poland) In-person

Power of many - BHTOM telescope network for time-domain astronomy,

The Black Hole Target and Observation Manager (BHTOM, bhtom.space) is a new platform for the coordination of time-domain observations. It accepts requests for targets for long-term or rapid photometric monitoring, such as transients, microlensing events, quasars, variable stars, and extrasolar planets, and collects data from a heterogeneous network of nearly 100 telescopes from around the globe. The observations from the telescopes are automatically processed and standardised in BHTOM in order to provide science-ready data.

I will present the system, its capabilities and the scientific results obtained so far. I will discuss how BHTOM can be utilized for photometric follow-up of targets and alerts discovered by Gaia, ZTF, ASASSN, and LSST in the future.

Contributed Talks

de Ruiter, Iris (Anton Pannekoek Institute, Amsterdam, Netherlands), Remote

Bridging the Spectrum: from Optical to Radio Transients

Radio follow-up of tidal disruption events, supernovae, gamma-ray bursts and electromagnetic counterparts of gravitational wave events provides a unique perspective on the intrinsic physical processes, probing different emission processes and providing high-resolution images. In this talk, I would like to discuss the current procedures of following optical transients in the radio, exemplified by the outburst of the recurrent nova RS Ophiuchi, and how these procedures might change in the future. In the LSST era, more and more transients will be identified in the optical wavelength. Therefore, it is necessary to consider for which types of sources radio follow-up will provide the most meaningful contribution.

Finally, there is the possibility for a symbiotic relationship between radio and optical transient astronomy. There are types of transients that are discovered in radio data, but warrant optical follow-up. A well-known source class in this regard is the fast radio bursts, but I will also show an example of a radio transient discovered in LOFAR transient search that warrants optical follow-up. Leveraging the sky coverage of the LSST one can search for coincident optical signatures of these radio transients. Further in the future, these types of transients may become more prominent as radio astronomy is about the enter a new era with the SKA and the ngVLA.

Gall, Christa (Niels Bohr Institute, UCPH, Copenhagen, Denmark), In-person

Science with the Danish 1.54m telescope in the era of LSST

Dedicated rapid follow-up spectroscopic observations of transient events in response to the alert stream from the Rubin Legacy Survey of Space and Time (LSST) alert brokers will be a scarce resource. The Danish 1.54-meter telescope (DK154) at ESO La Silla Observatory, in close proximity to the Vera C. Rubin Telescope, may help to tap the potential for transient science in the LSST era. I will Talk about current efforts undertaken to refurbish and modernize the DK154 that include the development of fast-response alert algorithm for automated spectroscopic observations. I will discuss transient science cases for which the DK154 telescope will be ideally suited.

Killestein, Thomas (University of Turku, Turku, Finland), In-person

The Gravitational-wave Optical Transient Observer (GOTO)

The Gravitational-wave Optical Transient Observer is a multi-hemisphere, modular, wide-field optical sky survey, designed specifically for challenging GW-EM follow-up campaigns

over large areas of sky: in search of kilonovae and other potential optical signatures. The project will survey the entire visible sky on a 2-3 day cadence, providing a rich dataset for a wealth of time-domain science that overlaps heavily with the aims of LSST.

This talk will give an overview of the GOTO project thus far, highlighting the design philosophy, key science results, and the innovative real-time dataflow that powers the low-latency discovery of transients in the vast quantities of data generated by 32 unit telescopes.

More 'local' transient surveys are highly complementary with LSST, jointly delivering a comprehensive picture of the time-varying sky, and providing a data-rich testbed for developing the techniques and algorithms that will power real-time discovery in the era of Rubin.

Primas, Francesca (ESO, Garching, Germany), In-person

Embedding DEI principles in ESO's mission

During the last decade, ESO has made significant progress in discussing DEI dimensions, which are part of the core values of the organization. In this talk, we will highlight some of the initiatives undertaken in recent years at ESO and the key role played by its Diversity and Inclusion Committee. The main focus will be on the changes implemented by the Observing Programmes Office in the review processes of telescope time requests. We will conclude the presentation with a quick look into the on-going and near-future DEI goals.

Pruzhinskaya, Maria (Laboratoire de Physique de Clermont, Clermont-Ferrand, France), In-person

SNAD: enabling discovery in the era of big data

In the era of wide-field surveys and big data in astronomy, the SNAD team (https://snad.space) is exploiting the potential of modern datasets for discovery new, unforeseen, or rare astrophysical phenomena. The SNAD pipeline was built under the hypothesis that, although automatic learning algorithms have a crucial role to play in this task, the scientific discovery is only completely realized when such systems are designed to boost the impact of domain knowledge experts. Our key contributions include the development of the Coniferest Python library, which offers implementations of two adaptive learning algorithms with an “expert in loop”, and the creation of the SNAD Transient Miner, facilitating the search for specific types of transients. We have also developed the SNAD Viewer, a web portal that provides a centralized view of individual objects from the Zwicky Transient Facility’s (ZTF) data releases, making the analysis of candidates in anomalies more efficient. Finally, when applied to ZTF data, our approach has yielded over a hundred new supernova candidates. We also identified unreported slow-evolving transients that are good superluminous supernova candidates, along with a few other non-catalogued objects, such as red dwarf flares, active galactic nuclei, RS CVn

type variables, and young stellar objects. The most intriguing transients have been reported to the Transient Name Server and have been followed up spectroscopically.

Russeil, Etienne (Laboratoire de Physique de Clermont (LPC), Clermont-Ferrand, France), In-person

Transient Classifiers for Fink: glimpses from the ELAsTICC data challenge

The Vera Rubin observatory and the Legacy Survey of Space and Time (LSST) is expected to detect millions of transients every night, for an entire operation period of 10 years. Identifying the objects for potential follow-up will require robust, fast, and reliable classifiers. Given the volume and complexity of its data and the relatively short processing time available for classification, Machine Learning (ML) algorithms are expected to play a key role. We present here the models and methods developed and implemented in the Fink broker to classify objects from the Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC). The models include binary classifiers for Supernovae Ia, Active Galactic Nuclei, Superluminous Supernovae (SLSN), and two broad deep Learning classifiers (CATS and SuperNNova). I will present in deeper focus the SLSN classifier method and performance. It uses a random forest based on tailored features motivated by Symbolic Regression. Results show that the model is able to successfully isolate SLSN including some Pair Instability Supernovae (PISN) events. Such classification constitutes a crucial step in the potential discovery of real PISN events inside the future data provided by LSST. Finally, I will discuss the challenges the extra complexity of LSST brings in comparison to data from the current Zwicky Transient Facility (ZTF) and present a few alternatives on how the problem can be circumvented.

Shugart, Alysha (Rubin Observatory / NOIRLab, La Serena, Chile), In-person

DEI @ NOIRLab and Rubin Operations

During this talk, we will discuss ongoing DEI program development and efforts that impact both NOIRLab and Rubin Operations. We will discuss the work accomplished by the DEI Committee, workplace culture development, and our flagship program for DEI at NOIRLab - Broadening Participation. There is much work ongoing to unite the DEI initiatives at the two centers, including the construction of a Rubin project-wide hiring toolkit. We will talk about this project and invite participation in a breakout discussion to gather input on this tool with a European lens.

Posters

Abdollahi, Hedieh (IPM, Tehran, Iran), Remote

The Isaac Newton telescope monitoring survey of local group dwarf galaxies

We conducted an extensive analysis of all satellites of the Andromeda galaxy observed by the Isaac Newton Telescope (INT) to provide a comprehensive catalog of long-period variable (LPV) stars. LPVs as tracers of star formation history (SFH) could illustrate a galaxy's evolution over time. Using LPVs, the SFR in age bins, the half-light radius, the RGB-tip, the distance modulus, the total stellar mass, and the AGB-tip are also estimated. Furthermore, we extend our study beyond cataloguing variable stars by estimating mass-loss rates of detected variable stars. Mass-loss plays a crucial role in star evolution, affecting stars' lifetimes, chemical enrichment of their surroundings, and their potential interactions in the ISM. A combination of ground-based observations and space-based telescopes was used to apply spectral energy distribution (SED) for LPVs based on a variety of photometric filters. Based on the amount of mass-loss of each satellite, it can be determined how long it takes to reignite the SFR in quenched satellites.

Abdollahi, Mahdi (Institute for research in fundamental sciences (IPM), Tehran, Iran), Remote

Hierarchical Classification of Variable Stars Using Deep Convolutional Neural Networks

The importance of using fast and automatic methods to classify variable stars for large amounts of data is undeniable. There have been many attempts to classify variable stars by traditional algorithms like Random Forest. In recent years, neural networks as classifiers have come to notice. This paper uses the Hierarchical Classification technique, which contains several models with same network structure. Our pre-processing method uses light curves and period of stars as input data. We consider most of the classes and subclasses of variable stars in OGLE-IV database and show that using Hierarchical Classification technique and designing appropriate preprocessing can increase accuracy of predicting smaller classes. We obtain an accuracy of 98% for class classification and 93% for subclasses classification.

Antier, Sarah (Observatoire de la côte d'azur, Nice, France), In-person

Follow-up of fast transient with LSST with GRANDMA

The recent convergence of several prominent multiwavelength facilities has transformed the field of high-energy astrophysics with discoveries of several new phenomena (e.g., gamma ray bursts afterglows, kilonovae, peculiar supernovae, tidal disruption events) in

the past decades. In my Talk, i will present the scientific program of the Global Advanced Rapid Advanced Network Devoted to Multi-messenger Addicts (GRANDMA) on fast transients detected by the Vera Rubin Observatory. As this survey detects hundreds of thousands of new sources each night, we are co-developing technology to automatically identify relevant targets, down to a couple per night using the existing wide field survey Zwicky and the broker Fink. We would combine our search with on-demand observations on ESO facilities' unique deep spectroscopic and imaging capabilities to better sample the light curves and the spectroscopic measurements of these fast transients.

Asquini, Laura (INAF - Osservatorio Astronomico di Brera, Milano, Italia), In-person

Dynamic scheduling system for the SOXS spectrograph

We present the scheduler for the Son Of X-Shooter (SOXS) instrument at the ESO-NTT 3.58-m telescope in La Silla, Chile. SOXS is a single-object, high-efficiency spectrograph covering the range of 350-2000 nm and a mean resolving power of R=4500. Its main purpose is UV-visible and near-infrared follow-up observations of astrophysical transients. SOXS will operate without astronomers on-site, which for the first time sets the challange to develop a fully automated scheduler. By interacting with different target databases, the software we developed is capable of preparing a night-by-night optimized schedule (in terms of observability constraints and scientific priority) and, by interfacing with the La Silla Weather API, it provides optimal backups in real-time, ensuring rapid-response capabilities without compromising observation quality. We developed a scalable architecture using Restful API applications like Docker Containers, API Gateway, and Python-based Flask frameworks. Here, we provide an overview of the design of the scheduler and its algorithms, along with insights into its web interface and preliminary performance tests.

Bauer, Franz (Universidad Católica de Chile, Santiago, Chile), Remote

4MOST-ChANGES - LSST Synergies

The 4MOST Chilean AGN/Galaxy Evolution Survey (ChANGES) plans to target ~10^6 AGN candidates, selected via variability and SEDs, in the Southern Hemisphere between 2025-2029. All will have coverage time series coverage from LSST, offering a variety of novel constraints. Additionally, ChANGES will target large samples of extreme variable AGN and TDE candidates selected by LSST and other facilities. I will present our plans with an eye toward LSST synergies.

Becerra, Rosa (Universita Roma Tor Vergata, Rome, Italy), In-person

Deciphering the unusual stellar progenitor of GRB 210704A

GRB 210704A is a burst of intermediate duration (between 1 and 4 seconds) followed by a fading afterglow and an optical excess that peaked about 7 days after the explosion. Their properties, and particularly those of excess, do not easily fit into the well-established classification scheme of GRBs as long or short and leaving the nature of their progenitor uncertain.

In this talk, multi-wavelength observations of this GRB and its counterpart, observed up to 115 days after the outburst, are presented. To decipher the nature of the progenitor system, we present a detailed analysis of the high-energy properties of GRB, its environment, and the late optical excess. We discuss three possible scenarios: a nearby short GRB, a distant long GRB, and a nearby exotic GRB, possibly in a galaxy cluster.

Bisero, Sofia (GEPI, Observatoire de Paris, Université PSL, CNRS, Paris, France), In-person

Spectroscopic follow-up of Rubin counterparts of GW detections from next generation interferometers

Gravitational wave (GW) multi-messenger (MM) observations of binary neutron star systems mergers (BNSs) are extremely challenging.

Next generation GW interferometers will revolutionize MM astrophysics, detecting thousands of BNS beyond the Local Universe. Electromagnetic (EM) optical counterparts of BNS detections will be faint and to be found within large error regions. Photometric observations with Rubin will provide counterpart candidates among a huge number of contaminants. To exploit such observations at best, spectroscopic follow-up observations are necessary to identify and characterize the EM counterparts, and they will be the bottleneck of GW-MM science.

In this context, I am exploring the possibility of using the next generation Integral Field Spectroscopy (IFS) and Multi-Object Spectroscopy (MOS) to this aim, in synergy with Rubin photometric observations.

I will present the results of the work I am carrying out within the Wide-field Spectroscopic Telescope (WST) science team and the MM division of the Einstein Telescope (ET) Observing Science Board to prepare WST observations to identify the EM counterparts of ET BNS detections.

Blagorodnova Mujortova, Nadejda (University of Barcelona, Barcelona, Spain), In-person

Predicting and studying stellar mergers in the era of large time-domain surveys

Luminous red novae (LRNe) are astrophysical transients with luminosities in between classical novae and supernovae. Usually associated with the merger of massive stars, their study provides important clues to understanding the physical processes involved in the binary common envelope evolution. This phase is believed to be the dominant production channel for compact binary pairs, such as gravitational wave progenitor sources. Despite its importance, this is also one of the least understood phases in binary

evolution. In this Talk, I will describe our strategy to combine LSST data with shallower, higher-cadence surveys, such as BlackGEM and ZTF to promptly identify the LRNe transients, or even predict them. All LRNe transients with pre-outburst history display a 2-5 years precursor phase when the source brightens considerably due to the copious mass loss, which also accelerates the merger process. The depth and color information of LSST will be ideal for the identification of these precursors several years before the LRN event. On the one hand, the study of these soon-to-be stellar mergers will allow us to determine which are the most important physical processes leading to the final collision. On the other hand, the coordinated follow-up and careful study of the outbursts themselves will reveal information about the energetics, ejecta geometry, and dust formation processes, which are needed to understand how the common envelope is lost.

Cruz Sáenz De Miera, Fernando (IRAP, Toulouse, France), In-person

Discovery of accretion-driven photometric outbursts and the need for quick follow-up observations

Accretion is among the most important physical processes during the formation of stars. Eruptive young stars are young stellar objects (YSOs) that experience sudden and dramatic accretion outbursts, where the mass accretion rate can increase by up to 5 orders of magnitude. These are commonly discovered via an optical/near-infrared photometric brightening of up to 6 magnitudes.

The last decade has seen the rise of multi-epoch all-sky surveys, with space telescopes like Gaia and WISE, and ground-based projects like ASAS-SN and ZTF. These surveys not only have helped to detect multiple new outbursts in young stars, but have greatly expanded our knowledge of these events.

In particular, the quick announcements of brightening events have allowed the community to promptly carry out follow-up spectroscopic observations, which have increased our knowledge of the changes in the disk (due to the increase of temperatures) and the star (due to the enhanced accretion rate) along the timeline of the outbursts.

Here I will present a brief overview of eruptive young stars and show examples of how the quick discovery of an outburst can result in follow-up observations that are necessary to improve our understanding of the effects these events have on the star and planet formation processes.

Dragana, Ilic (University of Belgrade - Faculty of Mathematics, Belgrade, Serbia), In-person

Quasar harmonic eXplorer (QhX): Supporting LSST Data Classification of Periodic Phenomena, (see submission by A. Kovacevic)

Authors: Andjelka Kovacevic, Dragana Ilic, Luka Popovic, Sasa Simic, Marina Pavlovic, Iva Cvorovic Hajdinjak, Isidora Jankov

Ederoclite, Alessandro (CEFCA, Teruel, Spain), In-person

Selecting interesting cataclysmic variables selected from the LSST brokers

The alert brokers of LSST are going to provide some preliminary classification of targets. Even for a class of objects like cataclysmic variables, which, so far, has proven to be comparatively small, the amount of alerts may become impossible to follow up.

In this context, after a selection is prepared in the framework of the Spanish Virtual Observatory, we will present a strategy to identify objects which are worth being followed up targets either with multi-filter photometry or spectroscopy.

Fedorets, Grigori (Finnish Centre for Astronomy with ESO (FINCA), Turku, Finland), In-person

Following up rapidly moving very small asteroids

Close flybys of the Earth by very small asteroids (1-10 m in diameter) provide opportunities for their physical characterisation. Very small asteroids contain objects of high interest, including e.g. imminent impactors, very close flybys, and minimoons. In addition to these targets, population-level studies of very small asteroids yield the variety of smallest blocks of the Solar System. Unfortunately, the observational windows for very small asteroids are very narrow, rendering rapid follow-up observations necessary. I would like to take the opportunity to present an ongoing effort, and to discuss the best approaches for planning rapid follow-up of small asteroids, the requirements, and constraints for such observations, and how they can be scaled up for the LSST era.

Fiscale, Stefano (Parthenope University of Naples, Naples, Italy), Remote

Utilizing LSST data for automated validation of planets in the habitable zone

In exoplanets detection, NASA's Transiting Exoplanet Survey Satellite (TESS) identifies thousands of candidates, and its successor, ESA's PLAnetary Transits and Oscillations of stars (PLATO), is expected to do the same with a focus on planets orbiting in the habitable zone. Since these surveys are characterized by a relatively low spatial resolution (21 and 15 arcsec/pixel for TESS and PLATO, respectively), the luminosity of different stars can be measured within a single pixel. When a candidate is identified, the possibility of it being generated by another source within the same pixel cannot be excluded and follow-up analysis is required to validate the candidate. The huge volume of data to be manually analyzed stressed the relevance to rely on automated methods. We propose an automatic pipeline for the validation of planet candidates that PLATO will detect, by employing Legacy Survey of Space and Time (LSST) and Gaia data. Exploiting the complementarity of these data in terms of spatial and photometric resolution, we expect to:

(i) be able to identify any false positive scenario up to the Gaia's precision of 0.059 arcsec/pixel;

(ii) extend the range of magnitudes (down to 23.5 guaranteed by LSST) within which false positives can be detected. We are developing this pipeline using data from LSST (Data Preview 0.2), Gaia (Early Data Release 3), and TESS, ensuring that only a fine-tuning will be necessary with the advent of real data from LSST (2025) and PLATO (2026).

Grupa, Jana (Max Planck Institute for Astrophysics, Garching, Germany), In-person

Gravitationally lensed supernovae as cosmological probes in the era of LSST

The HOLISMOKES (Highly Optimised Lensing Investigations of Supernovae, Microlensing Objects, and Kinematics of Ellipticals and Spirals) initiative focuses on measuring the current expansion rate of the universe independently from additional distance measurements using strongly gravitationally lensed supernovae. It includes the detection, lens modeling, measuring the time delays between the individual lensing images of lensed supernovae, as well as the possibility to unveil their progenitors.

This talk focuses on getting the time delays of lensed supernovae detected by LSST and observed by dedicated follow up observations. The needed instrumental requirements for the follow up to measure the Hubble constant with less than 3% uncertainty down to even 1% uncertainty in the era of LSST, are particularly focused on.

Hernitschek, Nina (Universidad de Antofagasta, Antofagasta, Chile), Remote

Variable Star Science with Community Brokers - Overview and goals

Variable phenomena, such as transients as well as periodic variable stars, play a key role in astronomy.

Many interesting objects in our Milky Way and beyond can be traced by periodic variables stars. This includes Stellar streams, as well as their progenitors – dwarf galaxies and globular clusters – which are of great interest because their orbits are sensitive tracers of a galaxy’s formation history and gravitational potential.

In the era of large-scale astronomical surveys, methods to investigate these data, and especially to classify astronomical objects, become more and more important. Community brokers play an important role especially for upcoming large surveys like LSST to deliver astronomical data and data products in nearly real-time to science users including participants in citizen science projects.

I will give a brief overview of state-of-the-art methods suitable especially for variable star science, as well as possible scientific use cases we wish to investigate with LSST.

Ivanov, Valentin (ESO, Garching, Germany), In-person

Let me look it up… – revealing the nature of new variable objects from archival precovery monitoring

The future synoptic projects, including the LSST, are preceded by a number of surveys, albeit shallower, or covering smaller areas or delivering a limited number of epochs. Nevertheless, this rich information trove can help to classify the newly identified variable objects, by providing either additional wavelength coverage or precovery monitoring. As a forerunner to the coming LSST avalanche of data, I apply this approach to the Gaia Alerts, using archival data from the VVV/X and VMC ESO public surveys and from the WISE satellite. Combining the optical Gaia colors and the infrared colors from these surveys helps to unambiguously identify young stellar objects and young stars. Furthermore, some precovery light curves show brightening of objects that were considered to have undergone microlensing events at a later date, during the Gaia coverage. The extremely low probability for multiple lensing events of the same star suggests that variability of these objects must be explained by other – and repetitive – mechanisms.

Izzo, Luca (INAF - Capodimonte, Naples, Italy), In-person

Classical novae in the Local Universe using the Vera Rubin Observatory and ESO facilities

With the advent of the Vera C. Rubin Observatory Survey, the detection and characterization of Classical Nova explosions (CNe) in the very nearby Universe (d < 10 Mpc) represents a tangible possibility. Recently, the interest in CNe has surged within the scientific community, driven by the discovery of Novae as high-energy sources, suggesting particle acceleration in a non-relativistic environment, potential neutrino emission, and their role as sources of Lithium and CNO isotopes. Pinpointing the rate of CNe in environments characterized by different star-formation and evolution histories represents the best methodology to reconstruct the chemical enrichment of nearby galaxies, and their stellar populations, as well as to quantify the role of novae as possible progenitors of type-Ia supernovae. I will emphasize the significant impact of the Vera Rubin Observatory on the identification of CNe in nearby systems by providing preliminary estimates for Nova discovery within 10 Mpc. Additionally, I will explore the potential contributions of ESO facilities to this field.

Kára, Jan (Astronomical Institute of Charles University, Prague, Czech Republic), In-person

Doppler tomography of cataclysmic variables in outbursts

Cataclysmic variable stars are semi-detached binary systems consisting of a white dwarf and a late-type secondary star overfilling its Roche lobe, which results in mass transfer onto the white dwarf primary. When no strong magnetic field is present, the transferred matter creates an accretion disc around the white dwarf. The accretion disc can be in an

unstable state, in which it can transition between low- and high-temperature states, leading to events of increased brightness called dwarf nova outbursts. The outbursts occur semiperiodically and the shape of their light curve can differ even in a single system. Some systems even exhibit superoutbursts, which are longer, more energetic, and less frequent than normal outbursts. Even though cataclysmic variables have been studied heavily in the past, the mechanism behind dwarf nova outbursts is still not fully understood. In my contribution, I will present an overview of different types of outbursts observed in cataclysmic variables and how ESO facilities can be used to study the accretion discs during these transient events.

Karmakar, Pradip (Madhyamgram High School (H.S.), Madhyamgram, India), Remote

Types Of Period Changes Of W Virginis Stars

There are still unsolved problems in understanding the evolution of type II Cepheids of the W Virginis class. Period changes of W Vir variables have the potential to provide insight into that evolution. We illustrate this by discussing the observed period changes of three W Vir variables in globular clusters. V2 in M10 shows a longterm decrease in period. V3 in M10, which is close to the dividing line between BL Her and W Vir variables, is nearly constant in period, possibly showing a small period increase. Sometimes, as with V1 in M12, irregular period changes make it hard to determine the long-term trend of the period.

Kornilov, Matwey (Lomonosov Moscow State University, Moscow, Russia), Remote

Coniferest: yet another Python package for active anomaly detection

We present coniferent, an opensource Python package for active anomaly detection. The package has been developed by SNAD team for active learning and currently implements two active anomaly detection algorithms: the Active Anomaly Discovery (AAD) technique proposed by Das et al., 2017, and PineForest approach proposed by SNAD team previously. Both techniques are based on Isolation Forest algorithm and allow a user to incorporate prior information (i.e. partially labeled data) as well as to run active learning loop (when the user is asked to label particular line of data). However, the techniques are implemented slightly differently. While the AAD is essentially an optimization problem with the given goal function and conventional optimization algorithms, the Coniferent uses genetic-optimization approach to sample the optimal forest.

Kovacevic, Andjelka (University of Belgrade-Faculty of Mathematics, Belgrade, Serbia), Remote

Supporting LSST Data Classification of Periodic Phenomena

Authors: LSST SER-SAG-S1 Team: A. Kovacevic, D. Ilic, L. Popovic, S. Simic, M. Pavlovic, I. Cvorovic-Hajdinjak, I. Jankov

We present the Quasar Harmonic Explorer, a tool for period analysis in quasar light curves, using cross-correlation of wavelet matrices. This complements traditional frequency domain period mining and enhances its utility in various research contexts.

The tool classifies periodic phenomena, supported by the Statistical Robovetter, which offers categorization with error and significance assessments and intersection over union metric. This provides reliable interpretations of detected periods.

Additionally, the Dynamic Visualization module simplifies representation of periodic signals as balls with radii of relative error across bands, making it user-friendly.

The tool's effectiveness is illustrated in the nonlinear regime of alerts, particularly in three-point data analysis. In a red noise simulation with a 10 Hz sinusoid, we interpolated three points from each flare feature. Auto-correlation maps of wavelet matrices for each triplet were calculated, showing topological map changes with amplitude and shape of triplets. Coherent clusters at 10Hz indicate significant alerts, while homogeneous maps suggest less significant flares.

In summary, the Quasar Harmonic Explorer is effective in analyzing light curves and detecting signals in triplet alerts.

Küppers, Michael (ESA/ESAC, Villanueva de la Cañada, Spain), In-person

Finding and Characterizing a Target for the Comet Interceptor Mission

Comet Interceptor is the first Fast (F-class) mission in ESA’s Cosmic Vision program. Its goal is the first in situ investigation of a long-period comet. Comet Interceptor (Spacecraft A) will carry two deployable probes, allowing multipoint investigations of the target. Probe B1 is contributed by JAXA and probe B2 by ESA. The mission will be launched in 2029 on an Ariane 6 towards the Sun-earth Lagrange point L2, together with the ARIEL mission. Comet Interceptor is the first rapid response mission, waiting in space at L2 until it will transfer to its target comet.

It is likely that the target comet for Comet Interceptor will be detected by LSST. To be reachable by Comet Interceptor, the comet needs to cross the ecliptic between 0.9 and 1.2 AU and be accessible with the available propellant. It is expected that a small number (1-5) of candidate targets for Comet Interceptor will be found before launch. To inform the target selection process, follow-up observations of the candidate targets will be required. Those include imaging (ideally in both the visible and thermal infrared wavelengths range) for determination of the nucleus size and rotation and detection and monitoring of activity and spectroscopy for gas production rates and composition measurements.

We will present the Comet Interceptor mission and its needs for follow-up observations of candidate target objects to ensure a scientifically successful flyby.

Leccia, Silvio (INAF Capodimonte, Napoli, Italy), In-person

Unveiling RR Lyrae Variables in the Galactic Bulge: Implications and Integration of LSST Observation

Focusing on RR Lyrae variables, key constituents of the old component of Galactic Bulge, during my talk I will investigate different Rubin LSST observational strategies, evaluating their impact on reconstructing the light curve of RR Lyrae stars and pushing the observational boundaries beyond the Galactic Bulge's established distance. As a starting point for our analysis a sample of nearly 500 RR Lyrae stars observed by DECAM in the Baade Window and described in Saha et al. will be used.

Furthermore, I will discuss the possibility of integrating Rubin LSST observations with other astronomical data to maximize scientific returns, particularly during the initial stages, enabling early science.

Leloudas, Giorgos (DTU Space, Lyngby, Denmark), In-person

The spaghettification of stars with a sauce of PESSTO

Massive black holes can disrupt and destroy entire stars when these are unlucky enough to cross their tidal radius. During the last decade, wide-field imaging surveys have discovered large numbers of tidal disruption events (TDEs) and spectroscopic surveys such as ePESSTO have provided important clues to their nature. The number of optically-discovered TDEs is expected to explode in LSST, offering an unprecedented opportunity to study black holes in quiescent galaxies that would otherwise remain invisible. I will present recent advances in the TDE field, such as the existence of “Bowen” TDEs, the measurement of spectroscopic lags between emission lines and continuum, the late-time appearance of coronal lines, and the first insights from spectral polarimetry, focusing primarily on results from the broader ePESSTO collaboration.

Levan, Andrew (Radboud University, Nijmegen, The Netherlands), In-person

The promise of gravitational wave counterpart follow-up at ESO

Identifying and studying the electromagnetic counterparts of gravitational wave sources remains a critical goal in contemporary astrophysics. These counterparts provide a unique route to measure heavy element enrichment, study the behaviour of matter at nuclear densities, constrain binary evolution channels and measure cosmological parameters. However, to date, we have only a single such detection, and it is now clear that building a sample of such events is a decade-long activity as gravitational wave observatories gradually increase their range. A consequence is that nearby, bright events akin to the single event seen to date (GW170817/GRB170817A/AT2017gfo) will be rare, and most sources will be substantially fainter. I will discuss the challenges of follow-up of these sources, including in their initial identification as the actual counterparts and

subsequently in obtaining sufficient data to reconstruct the transient properties. For the next GW observing run (O5), the combination of sensitive searches (e.g. via VRO), multiwavelength observations (e.g. gamma-ray burst coincidences) and substantial classification campaigns on 8m-class telescopes are likely to be necessary, and longer-term follow-up may require JWST/ELT sensitivity. I will argue that the considerable scientific returns justify the significant resources needed. Such campaigns exemplify science best pursued by larger collaborations that can represent the broad community of interested astronomers.

Malesani, Daniele (The Cosmic DAWN Center, Niels Bohr Institute, Copenhagen, Denmark), In-person

The most transient of them all: optical observations of long and short gamma-ray bursts

Detected by space observatories, long and short gamma-ray bursts and their afterglows are among the most luminous and variable transient phenomena in the Universe. Their physics share some similarities (they are both emitted in relativistic jets), but their progenitors sample different astrophysical environments: long GRBs originate from collapsing massive stars, thus being tracers of cosmic star formation. Short GRBs are instead produced in compact object mergers, and they probe heavy element nucleosynthesis and gravitational wave source populations.

I will present results from our long-term program carrying out absorption spectroscopy of GRB afterglows to probe gas, metal, dust, and molecules in high-redshift environments (a task demanding even for JWST), as well as their utility to constrain reionization.

ESO provides an ideal suite of instrumentation to fully exploit these sources. VLT and ELT will allow securing optical and NIR spectroscopy of the faintest, but also most valuable, events, such as high-redshift objects and the relatively unexplored short GRB afterglows. The SVOM mission (spring 2024 launch) is poised to enhance the detection of high-redshift GRBs. Moreover, with its daily cadence and unprecedented depth, LSST will detect (and characterise photometrically) both regular and "orphan" (jets not emitting observable gamma emission) afterglows, allowing to explore a more diverse and complete population of GRB jets.

Martin-Carrillo, Antonio (University College Dublin, Dublin, Ireland, In-person

SN 2023lcr: the first supernova from an orphan afterglow

Dirty fireballs are on-axis gamma-ray bursts (GRBs) with moderately relativistic jets, unable to create the bright flash of gamma-ray radiation characteristic of GRBs. Up to 2023, only 3 dirty fireball candidates had been observed. In June 2023 ZTF reported a new fast fading transient known as AT2023lcr, consistent with a GRB afterglow at z~1.03. Thanks to constraining pre-explosion imaging from GOTO, it was possible to tightly

constrain the time window of the explosion, when the gamma-ray prompt emission should have happened. Despite continuous coverage, no gamma-ray emission was seen by any of the GRB observatories, such as INTEGRAL and Fermi, allowing us to set tight limits on the prompt gamma-ray luminosity of this event. In terms of prompt vs afterglow emission, these limits make AT2023lcr one of the most inefficient GRBs jets ever observed to date. In this Talk, we will present the results from an intensive multi-wavelength campaign from radio to X-rays carried out to study the nature of this observationally rare GRB case. These observations are consistent with an on-axis afterglow at redshift 1.027, making AT2023lcr the best "dirty fireball" candidate observed to date. Late monitoring of AT2023lcr with VLT/HAWK-I, GTC, JWST and HST revealed the supernova associated with the orphan afterglow confirming its association with the collapse of a massive, stripped star, as seen in typical GRB-SN associations.

Melo, Alejandra (Max Planck Institute for Astrophysics, Garching, Germany), In-person

Strong-lens search through deep learning with both ground- and space-based imaging data

Lensed supernovae are ideal to investigate the supernova progenitor systems and for cosmological studies such as measuring the Hubble constant H0. To measure H0 with percent-level precision, the combination of multiple systems is needed, as already done with galaxy-quasar systems by the H0LICOW and TDCOSMO collaborations. While so far most lensed supernovae were detected only by chance and not through a dedicated search, dedicated effort is required for a sample that allows a combination of measurements. Since detecting these peculiar lenses through the supernova brightness often leads to small image separation systems with unresolved images that have too short time delays for measuring the Hubble constant, we present an alternative approach carried out within the HOLISMOKES collaboration.

We use all detected transients to cross-match with all known static lenses on a daily basis. For this procedure, dedicated and efficient lens search projects are a crucial step. I will introduce our ongoing search for gravitationally lensed transients using deep learning, where I have combined ground-based and space-based imaging using the Hubble Space Telescope (HST) and Legacy survey data, simulating Euclid and the Vera C. Rubin Observatory (LSST). I will present the steps and the different deep learning architectures that have been tested, and also summarize efforts from the whole community.

Nagy, Zsofia (Konkoly Thege Miklos Astronomical Institute, Budapest, Hungary), Remote

Accretion variability in Young Stellar Objects: results from the Gaia Photometric Science Alerts

Young stellar objects (YSOs) are accreting material from their disc via magnetic field lines. About half of them show daily-weekly photometric variations with an amplitude of a few

times 0.1 mag. Some YSOs show brightness variations on longer time-scales: months, years, centuries. Eruptive YSOs show brightness variations with an amplitude of a few magnitudes. These outbursts are caused by a sudden increase of the mass accretion rate by a few orders of magnitude. Eruptive YSOs are commonly divided into two main classes: EX Lupi-type stars (EXors) and FU Orionis-type stars (FUors). The former show brightenings of 2-4 mag, last for less than a year and are recurrent, the latter brighten by up to 5 magnitudes and last for several decades. So far the number of confirmed FUors is limited to no more than a dozen while the number of known EXors is limited to less than 25, including candidates.

The Gaia Photometric Science Alerts System, with its large sky coverage and approximately monthly cadence, provides an efficient tool to identify new eruptive YSOs. Based on the Gaia Science alerts, our group recently published the discovery of two FUors (Gaia18dvy and Gaia21elv), two EXors (Gaia20eae and Gaia19fct), and other types (e.g. Gaia21bty). Our follow-up observations include photometry using 1-m class telescopes, and spectroscopy using the TNG, the NOT, the NTT, the GTC, the LBT, and the VLT.

I will present results on follow-up observations of eruptive YSOs found from Gaia alerts.

Ngeow, Chow-Choong (Graduate Institute of Astronomy, National Central University, Taoyuan, Taiwan), Remote

RR Lyrae Distances to Two UDF Galaxies with Improved Metallicity and Theoretical PWZ relations

Segue II and Ursa Major II are two ultra-faint dwarf (UDF) galaxies. Using multi-band light curves for two RR Lyrae, one in each of these two UDF, together with multiple published empirical relations for estimating the photometric metallicity, we obtained a more precise photometric metallicity for these two RR Lyrae than those based on only a single relation. In this we present the measured distance moduli to these two RR Lyrae by applying the theoretical period-Wesenheit-metallicity (PWZ) relations and the improved metallicity measurements. The resulted distance moduli are fully consistent with those obtained from the empirical PWZ relations, demonstrating these theoretical PWZ relations can be used in distance determination. We briefly discuss the implication of our results in the era of Vera C. Rubin Observatory Legacy Survey of Space and Time.

Ngwane, Thobekile Sandra (University of Cape Town, Cape Town, South Africa), Remote

Developing Instrumentation and Software for Rapid Follow-up and Characterisation of NEAs

Near-Earth Asteroids (NEAs) are celestial bodies that have shifted from the asteroid belt to our solar system's proximity due to gravitational interactions with major planets, notably Jupiter. As of October 2023, the International Astronomical Union's Minor Planet Center

(MPC) has identified approximately 33,000 NEAs, with an average daily discovery rate of 11, thanks to dedicated survey programs like Catalina, Pan-STARRS, and ATLAS.

Our research focuses on rapid follow-up observations of newly discovered NEAs, using the South African Astronomical Observatory's 1-meter telescope, Lesedi, equipped with the Mookodi instrument. These observations are crucial because small NEAs quickly diminish in brightness as they move away from Earth's vicinity. Since starting our campaign in February 2023, we've successfully observed around 100 NEAs, including potential hazardous asteroids (PHAs).

Our findings, based on multi-filter photometry and astrometric measurements, have contributed to refining the orbits and designations of many NEAs. Additionally, g'r'i' photometry helps us approximate spectral slope and determine the likely Bus-DeMeo taxonomic type, revealing the composition of these NEAs.

Our research into the composition and structural integrity of these smaller yet potentially hazardous NEAs provides valuable insights into the nature of future impactors, enhancing our readiness for planetary defense against asteroid impacts. Our research enhances planetary defense against NEAs.

Opitom, Cyrielle (University of Edinburgh, Edinburgh, UK), In-person

Observing transients with CUBES: The future near-UV spectrographe for the VLT

CUBES is the forthcoming near-UV spectrograph to be installed at the VLT in 2028. CUBES will cover the 300-400nm range at high spectral resolution (R~20,000) with an efficiency 10x higher than UVES. The combination of high spectral resolution and efficiency of CUBES will enable ground-breaking results in various fields, from extragalactic astronomy to stellar nucleosynthesis and solar system science. Coupled with the Rapid Response Mode of the VLT, CUBES will also provide an exciting opportunity to observe transients at near-UV wavelengths, including gamma ray bursts and kilonovae.

Peel, Michael (Real Instituto y Observatorio de la Armada, San Fernando, Cadiz, Spain / Imperial College London, London, UK), Remote

Combining submm and optical transient detections

Simons Observatory will soon be starting survey observations, and will be discovering submm transient sources. This Talk will summarise the SO survey and expected detections, and potential methods to match them against optical transients.

Peloton, Julien (CNRS, Orsay, France), In-person

Deep dive into asteroid colors and spins in LSST era

With the advent of large-scale photometric surveys such as the ZTF and the Rubin Observatory, millions of Solar System objects (SSOs) are surveyed every night. The irregular cadence of these surveys precludes a simple determination of the colors of SSOs, whose photometry constantly varies due to their irregular shape and the ever changing Sun-SSO-Earth geometry.

We extended the phase function model (H, G1, G2, Muinonen+2010) to account for spin effects, which opens the possibility to use these large data set for the determination of both colors and spins of SSOs from their photometry. We applied it on more than 16 million ZTF photometric measurements from alert data processed by the Fink broker between 2019 and 2023. In this presentation, we will discuss results on colors, spin axis orientations, and shape elongations of about 100,000 asteroids, which constitutes a 10 fold increase in data volume with respect to the current knowledge. We will also discuss the community services in place in Fink to mine the Solar System data collected by ZTF, and the prospects for the Rubin Observatory.

Perez-Fournon, Ismael (Instituto de Astrofisica de Canarias, La Laguna, Spain), Remote

Follow-up of LSST transients with the Canary Islands telescopes

A large fraction of the LSST sky will be visible from the northern hemisphere.

In this presentation we will review the telescopes available and planned at the Canary Islands observatories for observations of LSST transients, from the optical to very high energy gamma rays. Several IAC groups and collaborators are planning the follow-up of LSST transients and variables, including supernovae, superluminous supernovae, and lensed supernovae, fast transients, and electromagnetic counterparts to gravitational waves. Collaboration with ESO LSST follow-up programmes would be very useful.

Pfalzner, Susanne (Forschungszentrum Jülich, Jülich, Germany), In-person

LSST will bring the decision between outer solar system models

Observations discovered many trans-Neptunian objects (TNOs) with completely unexpected orbital properties. Examples are objects like Sedna, which orbit at large distances on very eccentric orbits. But also the cold Kuiper belt population or even retrograde TNOs. Similarly, the TNOs' diversity in colour is still puzzling. There exist different theories concerning the process leading to the TNOs. The main hypotheses are: (i) that the TNOs were scattered there by the planets from an original position between the giant planets, (ii) a stellar flyby perturbed a more extended primordial disc of planetesimals, and (iii) a still existing or already ejected distant planet is responsible for the TNO orbits. The expected discovery of tens of thousands of additional TNOs will allow to provide the answer of which of these models is valid. However, to allow the testing of the

various models will require decisive predictions for each of these models. in this presentation, we will provide a first set of testable predictions for the flyby scenario.

Piranomonte, Silvia (INAF - Roma, Rome, Italy), In-person

Prospects and challenges for Opt/NIR counterparts of gravitational wave sources in the Rubin/ET era

Vera Rubin-LSST will play a key role in the newborn multi-messenger astronomy field allowing us to study and identify the likely faint and rapidly fading electromagnetic counterparts of the hundreds gravitational wave (GW) events expected by the 2nd generation GW detectors network at full sensitivity. It also will operate in synergy with other multi-wavelength facilities available for our teams GRAWITA (GRAvitational Wave INAF TeAm) and ENGRAVE (Electromagnetic counterparts of gravitational wave sources at the Very Large Telescope) expressly dedicated to this project.

In this talk, I will present all the activities we are carrying out to optimize the response of the Italian and European network of facilities to expected GW triggers, and how the team is working in the context of the search for electromagnetic counterparts of GW sources and their spectroscopic characterization, also in anticipation of the arrival of the Einstein Telescope, in which our large community is involved.

All the activities are expected to provide means and opportunities to the Italian and European astronomical communities to have a leading role in the GW and Time Domain Astronomy.

Pruzhinskaya, Maria (Laboratoire de Physique de Clermont, Clermont-Ferrand, France), Poster

Anomaly detection in the Fink Alert Broker

The detection of new astronomical sources is one of the most anticipated outcomes of the next generation of large-scale sky surveys. Experiments such as the Vera Rubin Observatory Legacy Survey of Space and Time are expected to continuously monitor large areas of the sky with remarkable deliberation, which will undoubtedly lead to the detection of unforeseen astrophysical phenomena. At the same time, the volume of data gathered every night will also increase to unprecedented levels, rendering serendipitous discoveries unlikely. In the era of big data, most detected sources will never be visually inspected, and the use of automated algorithms is unavoidable. I would like to present the anomaly detection module developed for the Fink community broker – one of the official LSST brokers – to search for unusual astrophysical events in the Zwicky Transient Facility alert stream and LSST in future. I will present the first discoveries made with the module including AT2023awt – rare subtype of AM CVn variables. The spectral and photometric follow-up observations of AT2023awt will be discussed. Other discoveries like fast transients, supernova candidates will be discussed. I will also Talk about the Fink anomaly

Slack- and Telegram-bot, which makes the process of anomalies analysis to be more efficient and convenient for the user.

Reguitti, Andrea (INAF-OAB, Merate, Italy), In-person

Precursors of Type IIn Supernovae in the era of LSST

Type IIn Supernovae are interacting transients which, in a growing number of cases, show signs of major variability in the progenitor's luminosity a short time before the final explosion.

In this talk, I will present the results of search for outbursts before type IIn SN explosions through archival data collected by current all-sky surveys and major astronomical observatories. I will also show the perspectives of what will be achievable in terms of distances and brightness of those events with the VRO-LSST survey.

For instance, with the depth of the LSST data, it will be possible to spot former S Doradus variability in the candidate LBV progenitors of nearby SNe IIn.

The future SoXS instrument, which will be mounted at the ESO 3.58-m NTT telescope, will also provide spectroscopic classifications and characterization of pre-SN outbursts that will be identified by LSST, which may herald a real, forthcoming SN explosion.

Ripepi, Vincenzo (INAF-Osservatorio Astronomico di Capodimonte, Napoli, Italy), In-person

Detecting and characterizing distant isolated RR Lyrae variables with Rubin LSST

Recent results from the literature have reported the presence of isolated RR Lyrae stars in the Milky Way halo well beyond 100 kpc and up to 300 kpc. These objects can help significantly in understanding the origin and evolution of the Galactic halo. In this context, the unprecedented time series observations from the Rubiin LSST will provide a unique opportunity to study these distant variables.

In this work, we aim to test our ability to detect, characterise and correctly classify RR Lyrae variables at increasingly large distances. Based on previous experience gained in the context of the Gaia mission,

we know that our goal can be reached if we can determine accurate periods, Fourier parameters, and peak-to-peak amplitudes. Indeed, these quantities are the most important attributes for machine learning algorithms devoted to the classification of the different variability types.

Therefore, we used a variety of RR Lyrae templates in the Rubin LSST bands and resampled them using the last baseline simulation (baseline_v3.0_10yrs) at varying distances and positions in the sky. The comparison between the input and output attributes (periods, Fourier parameters, and peak-to-peak amplitudes) allows us to predict the possibility of correctly classifying the distant halo RR Lyrae.

Rommel, Flavia Luane (Federal University of Technology - Paraná (UTFPR), Curitiba, Brazil), Remote

PSF photometry of small solar system objects from ZTF as preparation for LSST era

Our international collaboration has been improving community knowledge about the physical properties of Trans-Neptunian Objects (TNOs), Centaurs, and Jupiter Trojans using ground-based observations of stellar occultation events. The fundamental result of a stellar occultation event is a constraint on the object's size and shape. This 'stationary picture' analyzed along with the object's photometry can provide a tridimensional shape, a density estimation, and the object's geometric albedo. However, photometric observations are only currently available for some of these small bodies, and many dedicated observational runs are required to retrieve information about an object's rotational light curve and absolute magnitude. The Legacy Survey of Space and Time (LSST) operations are expected to begin in early to mid-2025, and one of the LSST key science drivers is the inventory of our planetary system, which includes hundreds of discoveries and follow-ups of small bodies in different filters over the ten years of the survey. The question is, will we be able to use this massive information, along with stellar occultation data sets, to characterize tens of these objects yearly? This work explores the PSF photometry measured by ZTF for some known small objects to build a Python pipeline and prepare ourselves for the LSST era. Here, we present the approach to retrieving the data, the analysis, and the first results for a short list of known objects observed by ZTF.

Sanchez Saez, Paula (ESO, Garching, Germany), In-person

SDSS1335+0728: A New AGN on the Horizon?

The galaxy SDSS J133519.91+072807.4 (hereafter SDSS1335+0728), which had exhibited no prior optical variations during the previous two decades, began showing significant nuclear variability in the Zwicky Transient Facility (ZTF) alert stream from December 2019 (as ZTF19acnskyy). The stochastic variability behaviour, coupled with the host-galaxy properties, suggests that SDSS1335+0728 hosts a ~10^6 solar-mass black hole (BH) currently turning on. In this Talk, I will present the discovery of SDSS1335+0728 and the photometric and spectroscopic follow-up conducted to confirm its nature, and I will discuss the lessons learned while studying SDSS1335+0728 for future discoveries of similar objects with LSST and ESO observations.

Sicignano, Teresa (Scuola Superiore Meridionale, Napoli, Italy), In-person

Type II Cepheids in the Rubin LSST era

"Type II Cepheids are useful distance indicators and stellar tracers for old populations. For instance, they have been used to find the distances of the Magellanic Clouds and to measure their tridimensional geometry.

Thanks to Rubin LSST we will able to detect and characterise Type II Cepheids in the Local Group galaxies and beyond. It is however important to know in advance to which distance and after how many years the survey cadence will permit us to correctly determine the period and the main features of the Type II Cepheids light curves.

To this aim, we have built ad hoc templates of all the subclasses of Type II Cepheids (BLHer, WVir, pWVir and RVTau) in the gri bands adopting a large sample of such objects observed by the Zwicky Transient Facility in our galaxy.

These templates have been resampled using the last Rubin LSST simulation (baseline_v3.0_10yrs) to evaluate the period, amplitude and mean magnitude recovery in a variety of positions in the sky and distances (distant galaxies). These data will allow us to verify up to which distances we are still able to classify correctly Type II Cepheids compared with classical Cepheids for which the templates in the Rubin LSST bands are already available within our group."

Solano, Enrique (Centro de Astrobiología (CSIC-INTA), Madrid, Spain), Remote

Characterisation of cataclysmic variables using the Virtual Observatory

Transients can be defined as astrophysical phenomena whose duration is significantly shorter than the typical timescale of the stellar and galactic evolution. Supernovae, novae, gamma-ray burst,..., are some examples of transient events.

Transients are often characterised using fast, multiwavelength follow-up observations. The use of the already existing information in astronomical archives using the Virtual Observatory can be a complementary approach.

In this poster we describe the methodology used to confirm hundreds of new cataclysmic variable from the Gaia and ZTF alert systems.

Sousa, Manoel Felipe (Federal University of Technology - Parana (UTFPR), Curitiba, Brazil), Remote

On the optical transients from double white-dwarf mergers

Double white-dwarf (DWD) mergers are relevant astrophysical sources expected to produce massive, highly-magnetized WDs, supernovae (SNe) Ia, and neutron stars (NSs). Although they are expected to be numerous sources in the sky, their detection has evaded the most advanced transient surveys. Here, we characterizes the optical transient expected from DWD mergers in which the central remnant is a stable WD. We show that the expansion and cooling of the merger's dynamical ejecta lead to an optical emission peaking at 1-10 days post-merger, with luminosities of 10^40--10^41 erg/s. We present simulations of the light-curves, spectra, and the color evolution of the transient. We show

that these properties, together with the estimated rate of mergers, are consistent with the absence of detection, e.g., by The Zwicky Transient Facility (ZTF). More importantly, we show that the Legacy Survey of Space and Time (LSST) of the Vera C. Rubin Observatory will likely detect a few/several hundred per year, opening a new window to the physics of WDs, NSs, and SN Ia.

Starling, Rhaana (University of Leicester, Leicester, UK), Remote

Rapid radio observations of gamma-ray bursts and their X-ray flares

Low frequency radio emission coincident with high energy pulses are predicted in some models for gamma-ray burst origins and for emission from relativistic jets. I will present observational efforts to detect or to set stringent limits on this emission using LOFAR and Swift, and discuss how future rapid-response campaigns can use this approach to study jet physics.

Suzuki, Nao (Florida State University, Tallahassee, USA), Remote

Optimizing Ground + Space Observations for Transient Science in the era of LSST, Roman and Euclid

We executed a transient survey with the Subaru Hyper-Suprime Cam and yielded a few thousand light curves. We performed quick classification with a limited number of data points and sent the best ones to the Hubble Space Telescope for IR observation. We successfully observed Type Ia supernova without making mistakes and now cosmological analysis is being conducted. For spectroscopic follow-up of host galaxies, multiplex spectrographs such as AAT and DESI are the most powerful allies. We are making a model case for the future survey, and we discuss the lessons we learned from the survey.

Tramuto, Alessandro Salvatore (University of Palermo/INAF, Palermo, Italy), In-person

Photometric Classification of Variable Young Stellar Objects

Young Stellar Objects (YSOs) show variability associated to a diverse range of physical processes, e.g., from accretion of material from the surrounding medium, to absorption due to warped disks, to rotational modulation due to spots.

I discuss the study of YSOs in the bluest bands (e.g., u, g, and r filters) available in Rubin LSST, using Color-Color and Color-Magnitude diagrams to mark the presence of accretion processes, explored using the Rubin Science Platform (RSP) Portal and Notebook aspects. I also present light curves of YSOs to study their peculiar variability and the physical causes behind it, also showing the possibility to apply this kind of study to different types of short-term variable stars. In particular, with an application to Data Preview Zero (DP0) simulated RR Lyrae variables, in the RSP.

Moreover, I discuss how the peculiar time scales associated to the variability processes in YSOs, that span from short-term variability of hours-days to long-term variability of months-years, can be caught taking advantage of high cadence visits (useful for short-term variability), and how we may take advantage of the whole duration of Rubin LSST main survey to probe the entirety of the long-term processes.

Tranin, Hugo (ICCUB - University of Barcelona, Barcelona, Spain), In-person

Census of extragalactic Hertzsprung gap stars to predict Luminous Red Novae in LSST

Large data volumes of LSST will make it difficult to find rare types of transients. Tracking them at very early times is even more challenging. In nearby galaxies, Hubble Space Telescope (HST) imaging offers an unrivalled means of finding, or even predicting transients based on their progenitor data.

Luminous red novae (LRNe) are intermediate-luminosity optical transients observed in the Milky Way and nearby galaxies. They uniquely probe the evolution of binary stars, as they represent the ejection of their shared envelope of gas, leading to the shrinking of their orbit, or their merger. Post-main-sequence stars are specially suited to initiate common envelope evolution, as they undergo a dramatic expansion in radius. As they enter the Hertzsprung gap and become yellow supergiants (YSG), any close companions interact with the donor transferred material, possibly leading to an initial mass loss (LRN precursor) and a final mass ejection from the system - the LRN.

By, combining stellar evolution models and statistical modeling, we compiled a catalog of over 200000 YSG candidates observed by HST in 387 nearby galaxies (<20Mpc). In my talk, I will explain the method for creating the catalog, and handling contaminants using multiwavelength data. I will also show the results of cross-matching this census with existing transients, including LRNe and supernovae. We argue that this approach could be adapted to identify other transients of interest based on their progenitor properties.

Valerin, Giorgio (INAF - Padova, Padova, Italy), In-person

Understanding Gap Transients in the era of LSST

The luminosity gap between the classical novae and standard supernovae (SN) is populated by a wide variety of phenomena. Among them we find the erratic eruptions of Luminous Blue Variable as well as mergers of non-degenerate stars in which the final product of the merger event is expected to survive (dubbed Luminous Red Novae, LRNe). Finally, perhaps the most mysterious among the so called "Gap Transients", there are the Intermediate Luminosity Red Transients (ILRTs), whose nature is still debated, but a promising scenario is that they arise from the explosion of an Electron Capture SN.

In this talk I will present the photometric and spectroscopic properties of LRNe and ILRTs, with special consideration for the opportunities that LSST will open up in the study of these objects. First and foremost, the sheer number of detected transients will be revolutionary

for this field, considering that only few tens of LRNe and ILRTs are known, to date. Furthermore, systems leading to the production of LRNe are visible in the optical domain even months or years before the merger, providing a powerful tool to observationally study the evolution of binary stars. Finally, I will discuss how to operationally identify these transients in the LSST database by employing a template light curve.

LSST will offer the chance to detect and characterise an unprecedented number of these understudied transient: we must be prepared.

van Roestel, Jan (University of Amsterdam, Amsterdam, Netherlands), In-person

Variable star science with the Zwicky Transient Facility

Although the Zwicky Transient Facility was primarily designed to study extra-galactic transients, it has also proven revolutionary for studying variable stars in our Galaxy. I was the ZTF-collaboration variable-star working group lead, and in my Talk, I will give an overview of how we used ZTF to detect and identify all kinds of variable stars. These include Galactic transients like dwarf novae and stellar flares; but also irregular (dipping) variable stars, and finally many periodic variables like eclipsing binaries and pulsating stars, including multiperiodic double eclipsing binaries and pulsators in binaries. I will discuss how the ZTF data has been used to study both populations of variable stars, but also how it is used to find unique and anomalous variable stars. With 2 billion lightcurves from ZTF, this resulted in a deluge of objects for followup. I will end my Talk with how we dealt with the huge amount of objects to followup; both with high-speed photometry and low-resolution spectroscopy and what we can learn for LSST.