SAAO PDP Postdoctoral Fellowship

Observing the Transient Universe

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Dr David Buckley, SAAO (dibnob@saao.ac.za), Principal Investigator of the SALT transient programme, on behalf of a large team of local and international collaborators.

Overview

This postdoctoral position is to support studies of astrophysical transients, including the on-going SALT Large Science Programme on transients, which has been running since 2016. It involves studies of transients across a broad range of object classes, including high energy (X-ray, γ-ray) and multi-messenger (gravitational wave, neutrino) sources and, since 2018, MeerKAT radio transients. In addition, with the 2019 launch of the Spektrum-RG X-ray observatory (with the eROSITA and ART-XC instruments), an expansion of transient followup of X-ray sources from this survey is anticipated. In addition there are also opportunities for involvement in the South African LSST transient programme, which involves preparatory work ahead of LSST, which begins commissioning in 2022/23. The latter will be a priority area of activity for this position.

Potential research topics

Due the wide scope of the programme, there is ample opportunity for participation in a number of areas of observational multi-wavelength transient astronomy, working with various collaborators and international teams. Some of the major topic areas currently under investigation, together with relevant publication outputs from the programme, are listed below:

1. *Preparing for transient followup with the Rubin Observatory Legacy Survey of Space & Time (LSST):*
   This involves participation as a part of a 9-person team which is tackling a variety of tasks within the LSST Tansient & Variable Star collaboration. This includes Machine Learning applications for the early characterization of transients plus developing integrated followup systems, both hardware and software. In addition mini-surveys with other facilities (e.g. MeerLICHT and KMTNet) will be utilized in order to test followup strategies with LSST.

2. *Transitional millisecond pulsars*: multi-wavelength observations, particularly radio and X-ray (e.g. de Martino et al. 2014, MNRAS 444**,** 3004; Coti Zelati et al. 2019, A&A 622, 21).
   These are rare but interesting Low Mass X-ray Binary systems for which SALT (and recently MeerKAT) has been making significant contributions, coordinated with space-based X-ray observations (e.g. with XMM-Newton). Plans are afoot for further MeerKAT observations of one new candidate system which was detected during Open Time observations in 2019.

3. *Unusual supernovae*: optical spectroscopy, spectropolarimetry (e.g. Vallely et al. 2019, MNRAS 487, 2372; Ping et al. 2020, ApJL 889, L6.)
   Recent work, particularly on core collapse and super-luminous supernovae, has been led by our Chinese and Indian collaborators and has involved followup on ASASSN-discovered sources. We aim to expand the South African involvement in this area.

4. *High energy transients, including GRBs and Gravitational Wave events*: optical spectroscopy (e.g. Abbott et al. 2017, ApJL, 848, L12; Buckley et al. 2018, MNRAS Letters 474, L71; Coughlin et a;. 2019, ApJL, 885, L19).
   The first electromagnetic counterpart of a GW event was strongly supported by observations at SALT and SAAO, with results featuring in 8 refereed papers. We are currently actively involved in efforts to

identify new counterparts of aLIGO/Virgo NS-NS and NS-BH events during the current O3 campaign and this will continue.

5. *Novae and related objects*: optical spectroscopy, multi-wavelength observations (e.g. Aydi et al. 2018, MNRAS 474, 2679; Aydi et al. 2018, MNRAS 480, 572; Geballe et al. 2019, ApJL, 886, L14).
   Synoptic multi-wavelength monitoring has resulted in a number of significant new discoveries which is changing our view point, particularly for those which emit at γ-rays.

6. *Cataclysmic variable and related objects*: spectroscopy, polarimetry, high speed photometry (e.g. Buckley et al. 2017, Nat Ast 1, 29; Maccarone et al. 2018, Nat Ast 3, 173; Breytenbach et al. 2018, MNRAS 484, 3831; Hakala et al. 2018, MNRAS 486, 2549; Khangale et al. 2020, MNRAS, 492, 4298).
   Some of these were transient followup of discoveries made from ASASSN, MASTER and TESS as well as coordinated multi-wavelength observations of magnetic CVs, including with the NICER X-ray telescope on the ISS.

7. *Compact binary X-ray transients* (Low Mass X-ray Binaries, High Mass X-ray Binaries): time resolved optical spectroscopy, high-speed spectroscopy (e.g. Paice et al. 2019, MNRAS 488, 512; Charles et al. 2019, MNRAS Letters 489, L47; Monageng et al. 2019, MNRAS 485, 4617).
   Both neutron star and black hole accretors are the subject of multi-wavelength time domain studies revealing both new objects and phenomena never seen before. This work has been particularly productive due to the ability of SALT to react fast to targets of opportunity and to undertake high time resolution observations.

Potential local collaborators

Apart from the proposer, others involved in some of the potential research areas include the following:
Professor Paul Groot (UCT & University of Neimegen, Netherlands)
Dr Enrico Kotze (SAAO)
Dr Itumeleng Monageng (SAAO)
Dr Vanessa McBride (UCT & IAU OAD)
Professor Pieter Meintjes (UFS)
Dr Stephen Potter (SAAO)
Dr Retha Pretorius (SAAO)
Dr Jessymol Thomas (SAAO)
Dr Brian van Soelen (UFS)
Professor Patrick Woudt (UCT)