TUVO: The Transient UV Objects Project

Searching for transients in the ultraviolet

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Transients







Accreting white dwarfs

Supernovae



X-ray binaries



Tidal disruption events



Active stars

1/16

Transient-searching facilities



Transient-searching facilities









Neutrino detectors

• Discover new types of sources/behaviour?

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Gezari+

3/16

2015

NUV

Supernova

PS1-13arp

21.0

21.5

22.0

22.5

23.0

23.5

The TUVO Project

- Aim: use currently operational space-based UV facilities to discover serendipitous UV transients
- What do we need?
 - 1. A UV facility with accessible real-time data
 - 2. A method for processing images to discover transients

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Swift and UVOT

- Space-based observatory dedicated to discovery of GRBs (BAT)
- X-ray/UV/optical follow up (XRT, UVOT)
- Many repeating observations of the same fields
- All data publicly accessible <6 hours after observations
- Operational for >16 years (lots of archival data)



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Image subtraction



Part I: Download UVOT data



Part I: Download UVOT data

Part II: Image subtraction





Science



Part I: Download UVOT data

Part II: Image subtraction

Part III: Photometry and lightcurve construction



Part I: Download UVOT data

Part II: Image subtraction

Part III: Photometry and lightcurve construction

Part IV: Catalog matching and source classification



Catalog queries

 Simbad (1)
 NED (2)

 2.88"
 1.08"

 Type: Assoc*
 Type: Infrared source

Other matches: ATLAS, XMM, XMM-OM, 12 Vizier catalog matches No matches: SkyBot, Gaia, ASAS-SN (V), ASAS-SN (T), ZTF, VSX, GCVS, TNS, GALEX, HST, PanSTARRS, CVCat, WISE, USNO-B, 2MASS Not queried: SDSS

Processed: 2022-01-04 22:06:32

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Cata	log	quer	ies
Simha	d (1)	

Simbad (1)	GAIA	ASAS-SN Variables (1)	ZTF	VSX (1)	GCVS (1)	PanSTARRS
1.2"	1.24"	1.67"	1.48"	1.2"	0.73"	Mag: - (G)
Type: Mira	Mag: 12.56 (G, Vega)	Type: Mira variable	Name: ZTF17aaaeeny	Туре: М	Туре: М	
	Distance: 3.36 ^{+1.23} _{-0.78} kpc	Mag: 14.5 (V)	Date: 2021-10-17	Mag: 11.1 - 17.00 V	Mag: 11.1	
	Parallax Sig.: 2.36		Mag: 14.88 (r)			
	Temp: 3300K		rb score: 0.4			

Other matches: NED, WISE, USNO-B, 2MASS, XMM, XMM-OM, 57 Vizier catalog matches No matches: SkyBot, ASAS-SN (T), TNS, GALEX, HST, SDSS, CVCat, ATLAS

Processed: 2021-10-22 12:24:45

Part I: Download UVOT data

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Processed: 2022-01-04 22:06:32



Analyse any interesting photometric behaviour more in detail



Discovery of a probable very fast extragalactic nova in a symbiotic binary (Modiano & Wijnands 2022, submitted)

Daily pipeline output

- List of candidate transients detected in all recent UVOT data
- For every transient candidate
 - Short-term (<1 week + template) lightcurve
 - Catalog matches and preliminary classification
- Long-term (up to 15 years) lightcurve for transients of high interest

Results overview

- In 2 years, we processed >100,000 images
- Every day, a few to few tens of real candidate transients are discovered
- Most are variable stars/binaries, accreting white dwarfs, AGN
- A handful are previously unidentified sources or unreported outbursts of known sources, i.e. **sources of high interest for TUVO**



Modiano+2022b

Sample of TUVO results

• Unreported novae and dwarf novae discovered (ATELs)

Sample of TUVO results

- Unreported novae and dwarf novae discovered (ATELs)
- Discovery of new accreting white dwarfs in outburst (Verberne+2020, Modiano+2022a)
- Archival studies of globular clusters (Modiano+2020)



Take-home message

- The UV range has hardly been explored to search for transients
- Searching for transients in the UV can lead to:
 - A better understanding of the physical mechanisms underlying known transient phenomena
 - Potentially discovering completely new types of sources or behaviour
- Through our TUVO pipeline, we search all Swift/UVOT data for serendipitous UV transients in near real-time as well as in the archive
- Initial results show that there is strong potential for interesting discoveries!

Archival UV studies - 47 Tuc



Modiano+2020

Follow-up strategy

- Ground-based spectroscopy
 - 2.5m INT
 - 10m SALT
- Further photometric multi-wavelength observations (Swift)





