STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Space Telescope Science Institute
2019 Spring Workshop Proposal
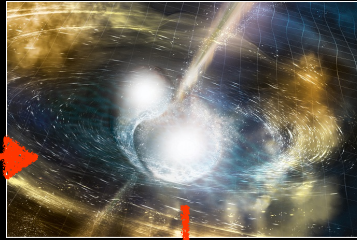
Gautham Narayan, on behalf of the SOC

07.09.18

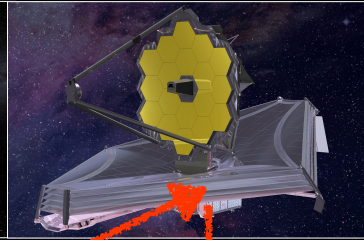# Enabling Multi-Messenger Astrophysics in the Big Data Era
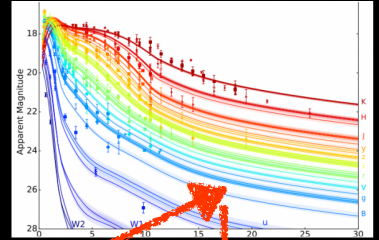## 2019 Spring Workshop Proposal

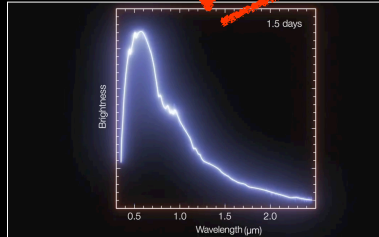**Rare Events**

Alert Brokers
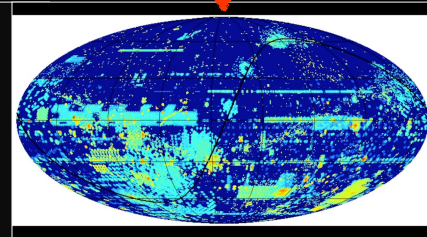
Prioritized Follow-up

Detailed Modeling

All-sky Surveys

Cloud Computing

Rich Multi-Messenger Data

Active Learning

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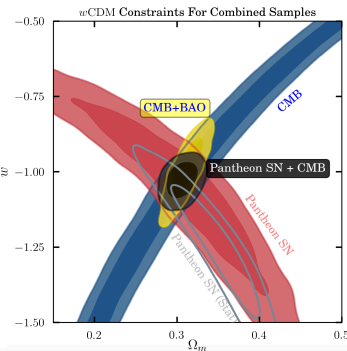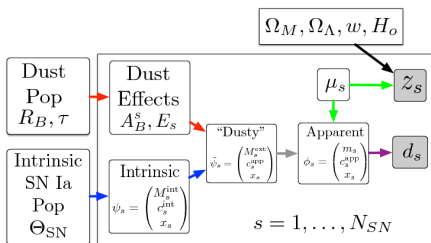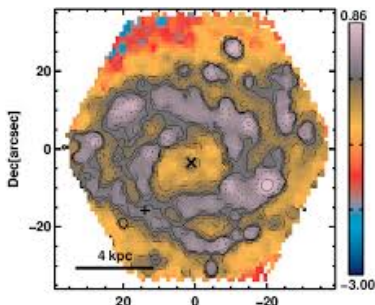
Enabling Multi-Messenger Astrophysics in the Big Data Era

Science Motivation

Stellar deaths and their afterlives are laboratories that test fundamental physics through astrophysics. These energetic events produce signals across the electromagnetic spectrum, and now in gravitational waves and neutrinos. Several ongoing or upcoming experiments (ZTF, LIGO, ATLAS, LSST, WFIRST, IceCube, SKA) will investigate these phenomena, and optimizing science return will need the community to combine, characterize, classify, filter, follow-up and analyze events from these big data streams.

Proposal

Our proposal is to conduct a two day spring workshop on "Enabling Multi-Messenger Astrophysics in the Big Data Era" immediately after the 2019 STScI Spring Symposium "The Death and Afterlives of Stars." The symposium will define the common needs of science community, while the workshop will connect select astrophysicists with the data scientists, statisticians and observatory personnel. Together, they will identify the key infrastructure that exists, and that needs to be developed to enable multi-messenger astrophysics in the big data era, and focus on building connections between the two.
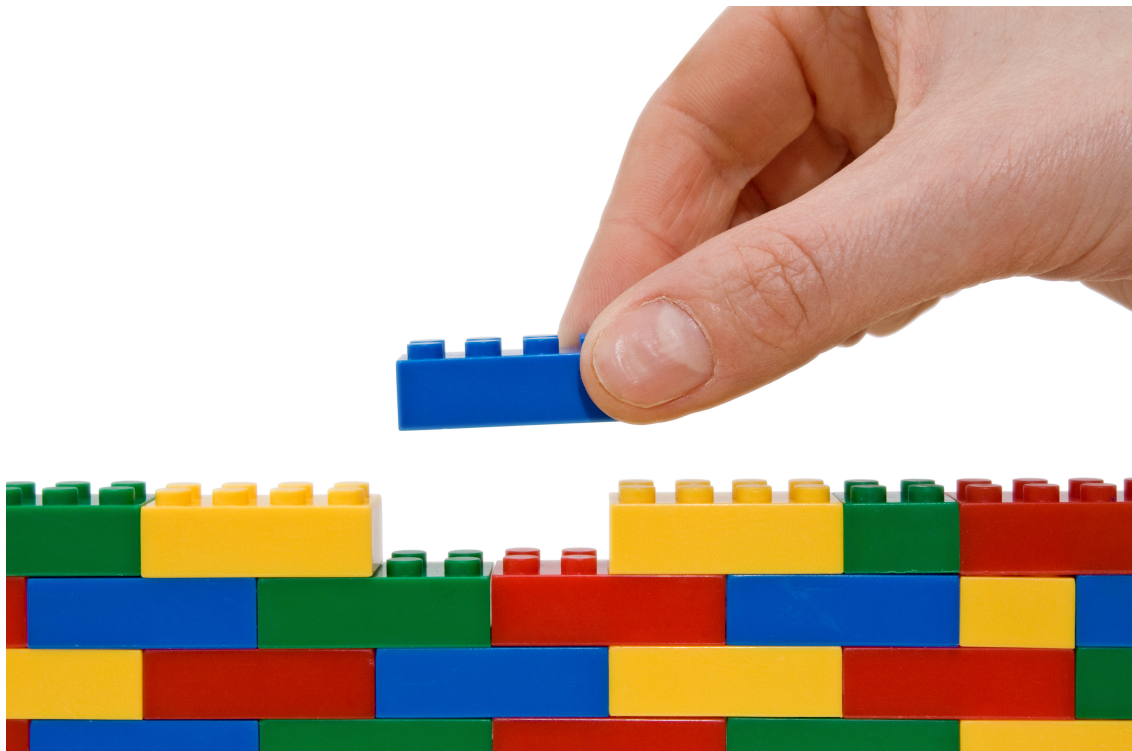
- How we do science is as important as what science we want to do!

- Our existing analyses do not scale

- Time on space telescopes is a critical limited resource

- **Focus on connecting infrastructure deliverables with science needs**

The convergence of discoveries like **GW170817**, new and upcoming observational facilities such as **LIGO, ZTF, LSST, JWST and WFIRST**, and **new data science and machine learning techniques** mean that we are on the precipice of a <u>**new era in transient astrophysics**</u>.

We will be probing new energy and time scales, while we understand much more about existing classes of transients, and how they connect with their host galaxies.

The NSF recognizes the need for changing how science is done in the coming decade in response to these developments, and asked for a white paper examining the field, which has concluded that there is a need for a "Center for Multi-Messenger Astrophysics"

<u>**STScI has the unique blend of expertise & facilities to be at the forefront of this era.**</u>

Key Science Themes Motivated by Leading Research Questions

Day 1 (4 of week)
"What infrastructure do we have?"

Morning (Connections to Symposium)
- **How** specific science cases made use of infrastructure (KN, SNIa surveys, SLSN, etc)
- What does community wish it had

Future priorities and strategies with JWST, LSST and WFIRST?
- How do we use limited follow-up resources with large photometric samples effectively
  - Emphasis on JWST and space-based resources
- How do we prioritize GW events and other rare sources of wide interest for rapid follow-up

Afternoon (Define what's needed)
Survey of current infrastructure
- What existing services and hardware will not scale?
- Lessons learnt by current wide-field surveys
- What services and infrastructure do observatories need to provide to make MMA vision a reality?

Key Science Themes Motivated by Leading Research Questions

Day 2 (5 of week)
"What infrastructure do we need?"

Morning (Define What's Being Built)
  - Demos from teams building future infrastructure
    - Focus on how we use machine learning, astrostatistics, cloud computing etc
      - alert brokers
      - data labs and archives
      - TOMS and follow-up systems

Afternoon (Connect needs with resources)
  - Setup three parallel hack sessions following morning groups
    - Focus on small feasible projects connecting science needs and infrastructure
  - Encourage attendance from key software developers and observatory staff

Similar Meetings and Key Differences

- Tools for Astronomical Big Data (NOAO, 2015)
  - A one-off meeting, while very successful, state of the field has already changed (new discoveries, new facilities)
  - Focused heavily on science with NOAO facilities, particularly DECam.
  - Many talks and discussions. Not designed to be hands-on

- Hot-Wiring the Transient Universe series (every two years in Fall, rotating)
  - More focus on standards and planning (IVOA VOEvent)
  - Not as clearly connected to science drivers
  - Also not designed to be hands-on

- Cosmostatistics Initiative Residence Program (every year)
  - Very limited number of participants (10 -15)
  - Focused entirely on developing techniques in astrostatistics, not implementation

We are designing our workshop to emulate the best aspects of these meetings, while emphasizing starting new projects at the intersection of data science, statistics and astrophysics

Science Organizing Committee

*Maria Drout (supernovae, kilnovae, follow-up)
*Ryan Foley (PS1, Foundation, YSE, WFIRST, supernovae, follow-up at scale)
Ori Fox (JWST/HST/Infrared Instrumentation/Observations)
*Renée Hložek (LSST DESC, astrostatistics)
*Mansi Kasliwal (ZTF, kilnovae, supernovae, follow-up)
Gautham Narayan (PS1, LSST, supernovae, ML, alert brokering)
Armin Rest (JWST, PS1, ATLAS, K2, supernovae, TDE, light echoes, pipelines)
Massimo Robberto (JWST, SCORPIO, instrumentation)
*Stephen Smartt (PSST, PS1, ATLAS, supernovae, follow-up at scale)
Arfon Smith (DSMO)
*Monika Soraisam (NOAO, novae, variable stars, big data infrastructure)
*Rachel Street (LCO, LSST TVS, automated followup, microlensing)
*Beth Wilman (LSST)

*external SOC members

Invited Speaker Candidates
(excluding expertise on SOC)

Existing Big Surveys - David Sand (DLT40), Chris Kochanek (ASAS-SN)

Future Surveys - Rebekah Hounsell (WFIRST), Mario Juric (LSST, ZTF)

Alert Streams - Maria Patterson (LSST, ZTF), Ken Smith (PS1, ATLAS)

Archives and Data Labs - Iva Momacheva (DSMO), Knut Olson (CSDC)

Machine Learning - Anais Möller (SNLS), Michelle Lochner (SKA)

Alert Brokers - Francisco Forster (ALERcE), David Young (LASSAIR, PSST)

Astrostatistics - Jacob VanderPlas (astroML), Kaisey Mandel (RAISIN), Ilya Mandel (Monash), Ben Farr (Flatiron/Stonybrook)

Active Learning - Emilie Ishida (LSST), Joshua Bloom (ZTF)

Organizing Principles

Workshop Goal
- The symposium will identify the needs of the community
- The workshop will address those needs by connecting scientists to resources they may not be familiar with, and highlight what needs are unaddressed
- Workshop attendees will be heavily skewed towards members of the community that are builders (hardware and software)

Diversity
- We will have a SOC with a 50/50 male/female representation
- We will have an invited speaker list with a 50/50 male/female representation
- We will have >30% speakers selected through contributed talks, and will ensure a diverse selection
- We will ensure a balanced distribution of students, postdocs, and faculty, and we will *actively* seek minority participation in the workshop

Workshop Structure
- We will structure the agenda to foster working on small projects (short talks 10+5, longer demos, focus on building
- SOC will organize an SDAS like reception to engage participants with others at STScI
- SOC members will organize and lead dinner parties at local restaurants

The Deaths and Afterlives of Stars
2019 Spring Symposium Proposal

Enabling Multi-Messenger Astrophysics in the Big Data Era
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