Search for High Energy Neutrinos from Populations of Optical Transients

Robert Stein
For the IceCube Collaboration
Neutrino Astronomy

Many Astrophysical Neutrinos

Enormous atmospheric background

IceCube Preliminary

IC2012-2016
Neutrino Astronomy

Many Astrophysical Neutrinos

Enormous atmospheric background

IC2012-2016

Rate per Bin / Hz

10^{-4}

10^{-6}

10^{-8}

10^{-10}

10^2 10^3 10^4 10^5 10^6 10^7 10^8

Muon Energy Proxy / GeV

IceCube Preliminary

Alerts

See Talk by Chun Fai

PoS(ICRC2017)1005
Neutrino Astronomy

Many Astrophysical Neutrinos

Enormous atmospheric background

Stacking Alerts

PoS(ICRC2017)1005
Leveraging the lower-energy neutrinos

- Central problem in neutrino astronomy is “too much background”. Knowing where and when to look can help us!
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- Central problem in neutrino astronomy is “too much background”. Knowing where and when to look can help us!

- “Stacking analyses” combines neutrino emission from many sources. We use lower-energy neutrinos to make statistically-significant statements on populations.
What are Tidal Disruption Events?

1. Star
2. Star distorted by tides
3. Accretion disk
4. Disrupted star

Particle jet
But what is a TDE? And what is not?

Nuclear Transients

TDEs
AGN
Nuclear SNe
But what is a TDE? And what is not?

Need pure TDE sample for neutrino analysis

This requires extensive photometry + spectroscopy

Of literature candidates: 12/60 “convincing” Non-Jetted TDEs, 3/60 Jetted TDEs

Stacking analysis performed on these TDEs using IceCube data from 2008 to 2017
IceCube constraints on TDE neutrino emission

(Hypothesis: TDEs are Neutrino Standard Candles)

Large uncertainties in constraints are driven by poor rate estimation from “traditional astronomy”.

NEW RESULT!

a: 2015ApJ...809...98A (IceCube Collab.)
b: 2018ApJ...852...72V (van Velzen)
c: 2015ApJ...812...33S (Sun et al.)

With evolution from Sun et al.
Large uncertainties in constraints are driven by poor rate estimation from “traditional astronomy”.

**NEW RESULT!**

**IceCube constraints on TDE neutrino emission**

(Hypothesis: Neutrino Luminosity proportional to $M_{BH}$)

- **NEW RESULT!**
- Large uncertainties in constraints are driven by poor rate estimation from “traditional astronomy”.

**Figure 1:**

- **IceCube constraints on TDE neutrino emission**
  - **Hypothesis:** Neutrino Luminosity proportional to $M_{BH}$
  - **NEW RESULT!**
  - Large uncertainties in constraints are driven by poor rate estimation from “traditional astronomy”.

**Figure Description:**

- **IceCube constraints on TDE neutrino emission**
- **Hypothesis:** Neutrino Luminosity proportional to $M_{BH}$
- **NEW RESULT!**
- Large uncertainties in constraints are driven by poor rate estimation from “traditional astronomy”.

**Legend:**

- **IceCube diffuse flux**
- **Jetted TDEs**
- **Standard Candle Limit**
- **$L_{\nu} \propto M_{BH}$ Limit**

**Graph:**

- **Diffuse fraction** vs. **Mean TDE BH Mass ($\bar{M}_{BH}$) [$M_\odot$]**
  - **IceCube Preliminary**
  - **Standard Candle Limit**
  - **$L_{\nu} \propto M_{BH}$ Limit**

**Notes:**

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- **b:** 2015ApJ...812...33S (Sun et al.)

**With evolution from Sun et al.**
Neutrinos from Optical Transients | Robert Stein | ICRC 2019

This Analysis

Tidal Disruption event (TDE)

<26%  <1.3%

Jetted

Non-jetted

Previous Analyses

<1%  <13%  <28%

Gamma-Ray Burst (GRB)  Supernova with choked jets  Supernova Type IIn

https://arxiv.org/abs/1601.06484

Preliminary (Publication in prep)
The universe has surprises in store for us!

AT2018cow

Extraordinary transient Candidate TDE? Nearby “Fast Blue Optical Transient” (FBOT)?

60 ATELs >10 papers!
Latest IceCube results...

AT2018cow neutrino emission limit (100GeV - 10PeV)

(Time-integrated emission in 130-day window)
Summary

- Transients provide an opportunity for searches with much-reduced background.

- No significant neutrino emission found from TDEs. Previous studies limited CCSNe contribution.

- No significant emission from AT2018cow, whatever it was.

- New surveys such as ZTF, and upcoming surveys such as LSST, mean multi-messenger datasets available will improve dramatically in the near future.

- Search continues for an identified neutrino source population