Live from AAS:

The Latest News from NASA Astrophysics Missions

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Julia Zachary (Wesleyan University)
Ian Steer (NASA/IPAC Extragalactic Database)

Facilitators: Brandon Lawton (STScI)
& James Manning (Universe of Learning)
Cosmic Double Whammy: Black-Hole Blast Followed by Galaxy Cluster Collision

van Weeren et al. (2017) Nature Astronomy, 1, 0005

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GALAXY CLUSTERS

- Most massive bound objects in the Universe
- Few thousand galaxies
- Filled with 10-100 million degree hot gas (plasma)

Cluster Formation

Chandra: X-ray emission (hot gas)

Hubble: visible light (galaxies)

Shocks form in the cluster gas
Merging clusters host Mpc-size radio sources: Radio Relics

Hypothesis: Radio relics trace electrons accelerated at shocks

Shocks have been detected with X-ray observations

Shocks are weak: How can these shocks accelerate electrons so efficiently?

X-ray emitting electrons $\rightarrow$ radio emitting electrons

energy increase: few million times
Abell 3411-3412

1 Mpc = 3 million l.y.

Cluster distance: 2 billion l.y.

radio relic

direction of cluster motion

Chandra X-rays

GMRT (610 MHz) Radio

Subaru (gri)
AGN - RELIC CONNECTION (II)

- Flat radio spectra → acceleration site
- Steep radio spectra → energy losses

1. Acceleration at AGN →
2. Energy losses in tail →
3. Re-acceleration at merger shock
RECAP & IMPLICATIONS

- **Particles jettisoned by a black hole receive a second energy boost from a galaxy cluster collision shock**
- **Shocks are weak: How can these shocks accelerate electrons so efficiently?**

- Low-frequency observations should reveal more AGN-relic connections

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Shock re-accelerate electrons from a black hole, only requires a mild energy boost

- Low-frequency (MHz)
- High-frequency (GHz)

“steep” radio spectral slope

Only bright at low frequencies
OUTLOOK

- Understanding re-acceleration physics: need accurate shock strengths

- Many sensitive low-frequency telescopes are coming online
  - LOFAR, MWA, uGMRT, SKA, ...

- Lynx: Candidate NASA Flagship mission
  - 50 times Chandra’s sensitivity
  - < 1 arcsec resolution

- Weak shock

- Shocks located in faint cluster outskirts → New X-ray satellite required
Measuring the local ISM along the sight lines of the two Voyager spacecraft with HST/STIS

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Poster 340.34
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Background

The interstellar medium (ISM) is the space between the stars containing clouds of gas and dust.

The interaction between the outward pressure of the solar wind and the surrounding ISM is the heliosphere, a bubble enclosing the Solar System.

The *Voyager* spacecraft are now moving out of heliosphere and into the ISM.

Credit: NASA/Goddard/Adler/U.Chicago/Wesleyan
Big picture

We obtain unique, simultaneous measurements - in-situ and line-of-sight - from two seasoned NASA missions, the *Voyager* spacecraft and the *Hubble Space Telescope (HST)*.

If the *Voyager* spacecraft are on a road trip through the galaxy, then they are the streetview to *HST*’s Google Maps.

With the announcement of Breakthrough Starshot, we now are considering missions through interstellar space and need to know about the structure of the ISM.
Spectroscopic measurements of the ISM

The black line is the observed HST spectrum, the gold line is the shape of the missing stellar emission, the dashed blue and purple lines are absorption from two ISM clouds, and the red line is the final combined fit to the data.
Conclusions

- We have acquired high-resolution spectra along sight lines that canvass the same ISM that the Voyager spacecraft are currently measuring, connecting two of NASA’s highly successful and enduring missions.

- We demonstrate that the local ISM into which the Voyager are moving is a complex and rich environment. Though we observe the closest stars in those directions, we see multiple ISM cloud absorbers.

- Like Voyager, we too measure electron density and find that one of the absorbing clouds has a similar density, while the other cloud’s density is slightly higher.

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How Far Away Is that Galaxy: Vast Catalog Has Answers

166,000 redshift-independent distance estimates for 77,000 galaxies now available in NED-D

Ian Steer, for the NED Team

The NASA/IPAC Extragalactic Database (NED)
Funded by the California Institute of Technology

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1. Distances to individual galaxies

2. Scale size for universe

3. Expansion rate for universe (Hubble constant)

4. Deviations from expansion rate (Peculiar Velocities)
166,000 redshift-independent distance estimates

77,000 galaxies with z-ind distances

2,200 references

75 different redshift-independent distance indicators
Growth of NED-D from 2006 to present

Distance Estimates

Galaxies w/ Distances

Online Year


N

180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000

20

AMERICAN ASTRONOMICAL SOCIETY MEETING 229, GRAPEVINE, TX, JANUARY 5, 2017
## How far is Messier 106

<table>
<thead>
<tr>
<th>Messier 106</th>
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<tbody>
<tr>
<td><strong>Constellation</strong></td>
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<td><strong>Right ascension</strong></td>
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<td><strong>Declination</strong></td>
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RED SHIFT-INDEPENDENT DISTANCES IN THE NASA/IPAC EXTRAGALACTIC DATABASE: METHODOLOGY, CONTENT, AND USE OF NED-D

IAN STEER¹, BARRY F. MADORE²,³, JOSEPH M. MAZZARELLA³, MARION SCHMITZ³, HAROLD G. CORWIN, JR.⁴, BEN H. P. CHAN³, RICK EBERT³, GEORGE HELOU³, KAY BAKER³, XI CHEN³, CREN FRAYER³, JEFF JACOBSON³, TAK LO³, PATRICK OGLE³, OLGA PEVUNOVA³, AND SCOTT TEREK³

The Astronomical Journal, Accepted: 2016 Oct 10

Estimates of galaxy distances based on indicators that are independent of cosmological redshift are fundamental to astrophysics. Researchers use them to establish the extragalactic distance scale, to underpin estimates of the Hubble constant, and to study peculiar velocities induced by gravitational attractions that perturb the motions of galaxies with respect to the “Hubble flow” of universal expansion. In 2006 the NASA/IPAC Extragalactic Database (NED) began making available a comprehensive compilation of redshift-independent extragalactic distance estimates. A decade later, this compendium of distances (NED-D) now contains more than 100,000 individual estimates based on primary and secondary indicators, available for more than 28,000 galaxies, and compiled from over 2,000 references in the refereed astronomical literature.
RECAP

Explosive growth in z-ind distances data

Accurate absolute vs. apparent properties for galaxies and cosmology

Maintained and updated for up to date data

Credit to astronomers

For astronomers and by astronomers
More news from AAS:

Brandon Lawton and James Manning discuss a few additional results and trends discussed at this week’s AAS meeting in Grapevine, TX.

Follow the updates on breaking news at AAS here: https://aas.org/astronomy-in-the-news
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