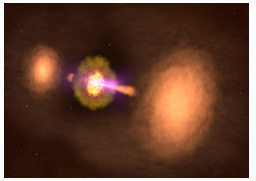
TXS 0128+554: A Young Gamma-Ray Emitting AGN With Episodic Jet Activity

M. L. Lister (Purdue), D. C. Homan (Denison), Y. Y. Kovalev (ASC Lebedev), S. Mandal (Purdue), A. B. Pushkarev (Crimean Obs.), & A. Siemiginowska (Harvard CfA)



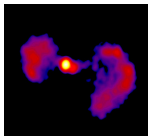
ABSTRACT: We have carried out a Chandra X-ray and multifrequency radio Very Long Baseline Array study of TXS 0128+554, which is associated with the Fermi γ-ray source 4FGL J0131.2+5547. The AGN is unresolved in a target 19.3 ks Chandra image, and its spectrum is well fit by a simple absorbed power-law model, with no distinguishable spectral features. Its relatively soft X-ray spectrum compared to other compact symmetric objects may be indicative of a thermal emission component, for which we were able to obtain an upper temperature limit of kT = 0.08 keV.

The compact radio morphology and measured advance speed of 0.32 c ± 0.07 c indicate a kinematic age of only 82 yr ± 17 yr, placing TXS 0128+554 among the youngest members of the CSO class. The lack of compact, inverted spectrum hotspots and an emission gap between the bright inner jet and outer radio lobe structure indicate that the jets have undergone episodic activity, and were relaunched a decade ago.

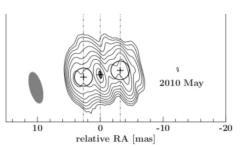
The predicted γ-ray emission from the lobes, based on an inverse Compton-emitting cocoon model, is three orders of magnitude below the observed Fermi-LAT flux. A comparison to other Fermi-detected and non-Fermi-detected CSOs with redshift z < 0.1 indicates that the γ-ray emission likely originates in the inner jet/core region, and that nearby, recently launched AGN jets are primary candidates for detection by the Fermi-LAT instrument.

I. Gamma-rays from Young AGN Jets

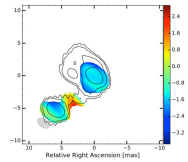
- Misaligned jets comprise ≲ 2% of the ~5800 AGN in the Fermi LAT catalogs (0.1 Gev – 300 GeV).
- TXS 0128+554 is a new addition to a rare class of young jets that have been detected by Fermi.
- All four of these AGN have jets with sub-luminal speeds oriented close to the plane of the sky.
- Their sizes range from 7 pc to 56 pc.



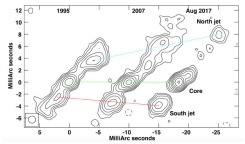
TXS 0128+554
(Lister et al. 2020, ApJ 899, 141)



PMN J1603-4904
(Müller et al., 2014, A&A 562,4)



PKS 1718-649
(Migliori et al. 2016, ApJ 821, 216
Angioni et al. 2019, A&A 627, 148)



NGC 3894
(Principe et al. 2020, A&A 535,185)

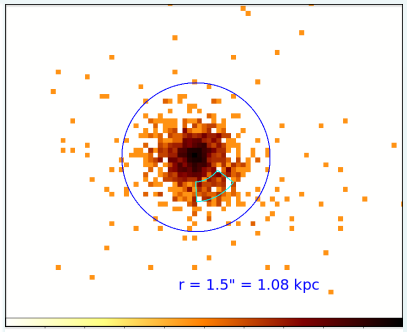
II. TXS 0128+554

- A compact radio-loud AGN (0.1 Jy at 15 GHz) with no kpc-scale radio emission.
- Hosted by an elliptical galaxy at z = 0.036
- Located within 95% confidence ellipse of a hard spectrum (Γ = 2.1) LAT gamma-ray source in 3LAC and 3FHL catalogs.
- Added to the MOJAVE VLBA program in 2016.
- Detected by ROSAT in keV X-ray regime.
- WISE infrared colors place it in the blazar color-color strip but outside the gamma-ray blazar region (Massaro et al. 2012).

Image from SDSS

III. Chandra X-ray Observations

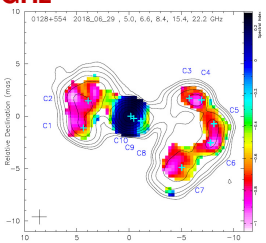
- Observed in March 2019 with Chandra ACIS-S.
- Data fit with absorbed power law model, photon index Γ = 2.4 between 0.5 keV and 10 keV.
- Possible hot thermal component present with kT < 0.08 keV.
- N_H column density of 6.7 x 10^{21} cm^{-2} consistent with N_{HI} – linear size relation for CSOs (Philström et al. 2003), but at high end of scatter.
- Larger overall neutral H fraction compared to other CSOs with similar total N_H .



The galaxy is a point-source X-ray emitter in a 19 ksec *Chandra* exposure.

IV. VLBA Observations 2.3 GHz – 23 GHz

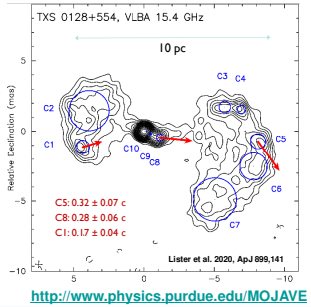
- Flat-spectrum core and inner jet region.
- Relativistic jets are inflating an ellipsoidal plasma cocoon ~ 16 pc in diameter.
- Strong flat spectrum core (T_b ~ 10^{10} K) indicative of current jet activity.
- No flat-spectrum (active) hotspots.
- C2 and C6 are aligned with inner jet direction.



Spectral index map from Lister et al. 2020, ApJ 899,141

V. Jet Properties

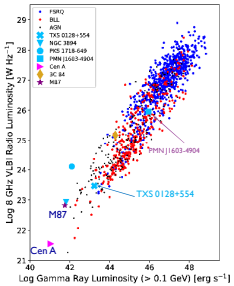
- 8 MOJAVE VLBA epochs at 15 GHz from 2016-2019.
- Cocoon expanding at 0.3 c, started growing ~80 yr ago.
- Jet viewing angle = 52° ± 8°
  → Eastern lobe seen at earlier stage of evolution.
- Gap in emission between inner jet and outer shell.
  → AGN launched a new inner jet a decade ago.
- Stawarz et al. (2008) cocoon IC/CMB model severely underpredicts the gamma-ray emission.
  → inner jet is the likely source of high energy emission.



http://www.physics.purdue.edu/MOJAVE

Summary

- TXS 0128+554 is a newly discovered member of a rare class of young gamma-ray emitting jets.
- It lies at low luminosity end of Fermi AGNs.
- It has similar size and age to NGC 3894 and PKS 1718-649, but a much higher 8 GHz radio core fraction (f = 0.48).
- All three have much lower luminosity than typical compact symmetric objects.
- Full details of this study are published in Lister et al. 2020, ApJ 899,141



Acknowledgments

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