I. Introduction

The nature of X-ray emission: Synchrotron X-rays


Inverse Compton X-rays -

Although the same processes producing X-rays through inverse Compton scattering are much more abundant, Lorentz factors of x = 10−20 are sufficient. Because electron cooling is typically very fast, populations of such electrons could travel much of the length of the jet. Moreover, we know from the radio synchrotron emission that there is a population of relativistic electrons in the jet. The question is whether IC scattering will take place, but whether it could dominate the X-ray flux. The relative strength of the observed emission depends upon the energy density of the population of such photons being upscattered by the relativistic jets, it is equivalent to an IC sink. If X-rays are observed, an optical measurement for upper limit that lies below a line interpolated between the X-ray and radio flux measurements rules out inverse synchrotron models.

Discriminating between the two

One way to distinguish IC from synchrotron X-ray emission is to consider the broadband spectral energy distribution (SED). The synchrotron spectrum produced by a power law distribution of electrons will either be a straight line in the log ν - log M plane or concave downward due to the beaming, or, in the case of the source in question, Lorentz factors of x ≳ 10−20. The relative strength of the observed emission depends upon the energy density of the population of such photons being upscattered by the relativistic jets, it is equivalent to an IC sink. If X-rays are observed, an optical measurement for upper limit that lies below a line interpolated between the X-ray and radio flux measurements rules out inverse synchrotron models.

II. The initial survey

Our survey is based on a sizable, well-defined sample of flat spectrum radio quasars (FSRQs). For this, the X-ray, optical, and radio data all provide subarcsecond imaging, allowing us to resolve structures in all three wavebands and enabling us to constrain how the physical conditions change along the length of individual jets.

III. Imaging results from the first phase

We have discovered X-ray jets in five of our Chandra counterparts, indicating that X-ray emission is a common feature of quasar jets. We consider this X-ray jet incidence rate of two-thirds to be a lower limit because of the variability seen in the jets. We have observed enough X-rays and also synchrotron radiation is well studied, and there is much we don’t know about them. The Lorentz factor of the relativistic electrons is the strength of the intrinsic magnetic field, or simply the de-projected geometry. Even something as fundamental as the process giving rise to X-rays is not understood, so we can’t use synchrotron radiation and inverse Compton scattering as possibilities. It would help us identify our 4-30 keV emission, if we could determine how much is due to the one or the other of these processes dominates. Furthermore, there is a lack of studies that attempt to determine the correct emission model in order to translate X-ray data into physical conditions.

Our survey is designed to study the distribution of emission processes and physical conditions among a sizable, well-defined sample of quasar counterpart jets. Our X-ray, optical, and radio data all provide subarcsecond imaging, allowing us to resolve structures in all three wavebands and enabling us to constrain how the physical conditions change along the length of individual jets. We have discovered X-ray jets in five of our Chandra counterparts, indicating that X-ray emission is a common feature of quasar jets. We consider this X-ray jet incidence rate of two-thirds to be a lower limit because of the variability seen in the jets. We have observed enough X-rays and also synchrotron radiation is well studied, and there is much we don’t know about them. The Lorentz factor of the relativistic electrons is the strength of the intrinsic magnetic field, or simply the de-projected geometry. Even something as fundamental as the process giving rise to X-rays is not understood, so we can’t use synchrotron radiation and inverse Compton scattering as possibilities. It would help us identify our 4-30 keV emission, if we could determine how much is due to the one or the other of these processes dominates. Furthermore, there is a lack of studies that attempt to determine the correct emission model in order to translate X-ray data into physical conditions.

IV. Jet–Radio–Optical–X–Ray SEDs

The optical upper limits rule out simple synchrotron scattering, favoring instead inverse Compton scattering as the origin of the X-ray emission.

V. The latest Chandra observations

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VI. The incredible jet of PKS 1427-490

We have identified the optical counterpart of PKS 1427-490, and have discovered that the jet is optically dominated and uniquely powerful.

PKS 1427-490 was the only member of our sample without an identified optical counterpart. We found it using five-band imaging in three filters last spring, discovering a 24.5 magnitude source in the radio position. The 5.0 mag source is shown in the top left. The g’ and r’ colors are consistent with quasars at z = 3.5-4.0 (Richards et al. 2002, AJ 123, 2445), which would make this the most distant source in our sample. We will measure the reddening this spring. The optical jet is shown with 8.6 GHz radio contours overlaid at left. Al in PKS 1427-490 L Bowen 1421-490, is the first quasar jet observed in X-rays by its jet, which provides 98% of the flux.

On the horizon...