Fine Morphology of Galactic Center Non-thermal Filaments Revealed by Deep Chandra Observation

Shuo Zhang
Einstein Fellow
Boston University

December 4th 2019
for 20 Years of Chandra Symposium
Meerkat revealed $>100$ radio filaments within 430 pc of Galactic Center
Tracing locally+globally ordered magnetic field and relativistic particles

Heywood+, Nature, 2019
MeerKAT shows association btw filaments and radio/X-ray bubbles

The event which generates the bubbles could be source of the relativistic particles that illuminate radio filaments

Heywood+, Nature, 2019
Survey of Galactic Center X-ray Filaments using Chandra, XMM-Newton and NuSTAR

17 filaments by Chandra
Johnson, Dong & Wang 2009

> 20 filaments detected by XMM
Ponti+ 2015

4 hard X-ray filaments by NuSTAR
Zhang+ 2014, Nynka+ 2015, Mori+ 2015
Filaments within 430 pc of the Galactic Center

<table>
<thead>
<tr>
<th></th>
<th>Radio Filament</th>
<th>X-ray Filament</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>&gt;~ 100</td>
<td>&gt;~ 20</td>
</tr>
<tr>
<td>Length</td>
<td>tens of pcs</td>
<td>a few pcs</td>
</tr>
<tr>
<td>Polarization</td>
<td>Detected</td>
<td>--</td>
</tr>
<tr>
<td>Feeding source</td>
<td>GeV electrons</td>
<td>TeV electrons</td>
</tr>
<tr>
<td>Origin of CRs</td>
<td>Particle acceleration/dark matter annihilation</td>
<td>Particle acceleration/secondary products of hadronic process</td>
</tr>
</tbody>
</table>
Most recent Chandra Sgr A* Complex observation from 2015-2017 (PI: Clavel):
10 observations, 460 ks

- More than 10 X-ray filaments captured in this dataset, some of which could be newly discovered (needs further verification).
- With approved 150 ks NuSTAR observation for this region in 2020 spring, targeted at studying filaments (PI: Zhang)
Chandra 2-8 keV

Intensity Profile

NuSTAR 10-79 keV

Length = 3.4 pc
Width = 0.1 pc
Distance to Sgr A* ~ 30 pc
Right next to Radio Arc
A point source detected in the middle shows slight curvature sharp edge on one side, while more fuzzy on the other side

Zhang+ 2019, under review
To answer...

- What are the sources of the GeV/TeV particles feeding radio/X-ray filaments in the Galactic Center, PWN, SNR, and/or SMBH?

- How is such ordered magnetic field structure formed?

- What fraction of the X-ray filaments share the same origin as the radio filaments?

We need...

- A systematic comparison between Chandra and MeerKAT deep Galactic center observations

- Future high spatial resolution and high-throughput X-ray missions like Lynx