Unidentified Infrared (UIR) Bands Associated with Extended Structures of Galaxies Based on AKARI Observations

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AKARI Mission

70cm SiC mirror
180L LHe + cryocoolers
on a 700km sun-
synchronous polar orbit
18 month cold mission
(2006.2-2007.8)

All-sky survey surpasses
IRAS database
+
Pointing observations
of imaging and
spectroscopy
in 2-180\(\mu\)m

2-5\(\mu\)m continued
AKARI Onboard Instruments & Capabilities

Two instruments onboard
IRC (Infrared Camera: 2-26μm)
& FIS (Far-Infrared Surveyor: 50 - 180μm)
AKARI Catalogues & Results

Point Source Catalogues (9, 18, 65, 90, 140, & 160µm bands) released in March
870,000 in MIR & 430,000 in FIR

The 3rd special issue of AKARI published in A&A this month

Kaneda et al. on M82
Onaka et al. on NGC1569

+
Unidentified Infrared Bands (UIR bands or PAH bands) at 3.3, 6.2, 7.7, 8.6, 11.3\(\mu m\) are ubiquitously seen in normal spiral galaxies. But the formation and destruction processes are not well understood.
AKARI Infrared Camera (IRC) Imaging Bands

S7: 6.2 & 7.7μm UIR bands
S11: 11.3μm UIR band
Red Hα, Green 7µm

3.2µm (B), 7µm (G), & 15µm (R)

Very Extended emission in MIR & PAH

Good correlation between 7µm and Hα at low flux level (R ~ 0.8)

Engelbracht et al. (2006)

Kaneda et al. (2010)
IR Emission in Halo

Contours: X-ray

Faint emission in 7 and 11 µm at the X-ray cap

If dust is entrained by outflow, it takes ~5 Myr to reach the halo (~3 kpc).

How do grains and PAHs survive?
Relatively constant MIR color of the extended emission

$7/15\mu m$ is lower at the X-ray emitting region

Destruction of smaller grains?
Extended FIR emission in NGC253


FIR emission associated with X-ray
Dust entrained by outflow must survive for 4-30 Myr
Energy may come from interaction with HI or plasma heating?
Observations of NGC1569

Nearby starburst dwarf \((12+\log(O/H) = 8.13)\)
Several Ha filaments produced by galactic wind

TO, H. Matsumoto et al. (2010)
UIR band emission associated with H$\alpha$ filament

7$\mu$m emission well correlated with a H$\alpha$ filament, which is created by galactic wind as indicated by X-ray emission
3.3, 6.2, 7.7, (8.6), 11.3 µm emission detected in the filament

The filament age is ~ 1 Myr
PAH destruction timescale ~ 1000 yr
PAHs produced by fragmentation in shocks?
The 7.7/11.3µm ratio is smaller & the 7.7µm band is narrower in the filament than in the disk. Environmental effects (low ionization) or else?
Comparison with other galaxies

Lower ratios are seen in elliptical galaxies and galaxy halos attributable to a common mechanism?
NIR Excess Emission in the filament

Surface Brightness (MJy/sr)

Wavelength (μm)

NIR excess emission seen in normal galaxies

Not stellar photosphere nor free-free

Hot dust emission?

868K BB/λ²
Merging galaxy NGC2782

Nearly head-on merger of 200 Myr ago
A less massive galaxy collides from west

Smith 1991 AJ, 378, 39

Eastern structure is only discernible in visible and NIR (stellar component without ISM)
UIR bands associated with HI

- $3.2\,\mu m (B) + 7\,\mu m (G) + 15\,\mu m (R)$
- $7/15\,\mu m (R) + HI$ (contour)

Filamentary structures in the east side are only seen in $7$ and $11\,\mu m$ and well correlated with HI emission. HI and PAHs are stripped together in merger and/or PAHs are formed by fragmentation in cloud–cloud collisions?

Star-formation is active in the western part, seen in structures in $15\,\mu m$
Several MIR and FIR features are seen in extended structures of galaxies, which are thought to be produced by outflow.

If dust grains and PAHs are entrained by outflow, then how do they survive in hot plasma environments or PAHs are formed by shocks?

Observations suggest that $7.7/11.3\mu m$ band ratio is smaller in halos and/or filaments than in disk. Formation process or plasma processing make the difference?

MIR spectroscopy of faint extended emission (with JWST and SPICA) and high spatial-resolution observations of Herschel would be valuable for the dust processing and formation
Thank you for your attention