The curious case of the ultra fast outflow in IRAS17020+4544

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We report the detection of a sub-relativistic outflow observed in the Narrow Line Seyfert 1 Galaxy IRAS17020+4544 as a series of absorption lines corresponding to at least 5 absorption components with an unprecedented wide range of associated column densities and ionization levels and velocities in the range of 23,000-33,000 km/s, detected at X-ray high spectral resolution (E/ΔE~1000) with the ESA's observatory XMM-Newton. The charge states of the material constituting the wind clearly indicate a range of low to moderate ionization states in the outflowing gas and column densities significantly lower than observed in highly ionized ultra fast outflows.
We estimate that at least one of the outflow components may carry sufficient energy to substantially suppress star formation, and heat the gas in the host galaxy. IRAS17020+4544 provides therefore an interesting example of feedback by a moderately luminous AGN hosted in a spiral galaxy, a case barely envisaged in most evolution models, which often predict that feedback processes take place in massive elliptical galaxies hosting luminous quasars in a post merger phase.

Results from X-ray Spectroscopy of IRAS17020+4544

Longinotti et al. 2015- ApJ Letters 813 39

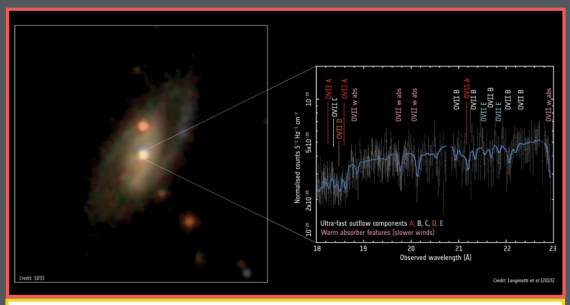
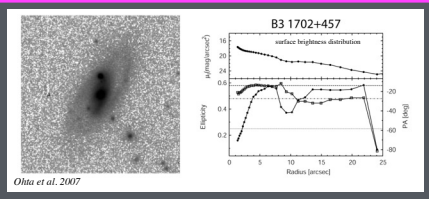


Table 2
Parameters of the Five UFO Components Detected in the RGS Spectrum

UFO Component Index	log U (erg cm s^{-1})	Log N_H (cm^{-2})	v_{out} (km s^{-1})	Statistics ΔC_{stat}	Significance
Comp (A)	$-0.39^{+0.30}_{-0.15}$	$21.47^{+0.18}_{-0.21}$	23640^{+120}_{-80}	45	9.0σ
Comp (B)	$-1.99^{+0.33}_{-0.20}$	$20.42^{+0.21}_{-0.38}$	27200^{+240}_{-240}	26	5.3σ
Comp (C)	$2.58^{+0.65}_{-0.65}$	$23.99^{+0.66}_{-0.66}$	27200^{+200}_{-200}	10	3.6σ
Comp (D)	$0.33^{+1.70}_{-0.40}$	$21.42^{+0.84}_{-1.28}$	25300^{+240}_{-240}	12	2.6σ
Comp (E)	$-2.95^{+0.71}_{-0.14}$	$19.67^{+0.34}_{-0.36}$	33900^{+350}_{-250}	10	2.0σ

Note. The statistical improvement (fifth column) refers to the addition of each PHASE component to the model comprising the continuum, the warm absorbers, and the previous UFO components. The significance is estimated through Monte Carlo methods.

Morphology of IRAS17020+4544



Ohta et al. 2007

-IRAS17020+4544 host galaxy is a barred Spiral
-L_{bol} ~ 5×10^{44} erg s^{-1}, significantly lower than most AGN with feedback from X-ray winds (QSO, ULIRG)
-No evidence of merger/disturbed morphology/dust obscuration
-Small black hole ~ 6 ×10^6 $M_\odot$

-High Accretion Rate L_{Bol}/L_{EDD} ~0.7

Feedback properties in IRAS17020+4544 in terms of the covering factor Cf

Assuming the outflow velocity of the wind is equal to the escape velocity:

$$r = \frac{2GM_BH}{v_{out}^2}$$

$$\dot{M}_{out} = 4\pi\mu r N_H v_{out} m_p C_f$$

$$\dot{E} = \frac{1}{2}\dot{M}_{out} v_{out}^2$$

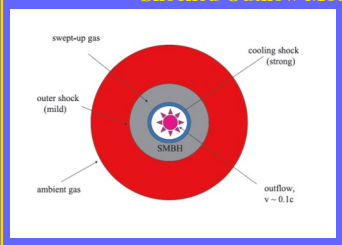
UFO component C
N_H~10^{24} cm^{-2}
v_{out}~27,000 km s^{-1}

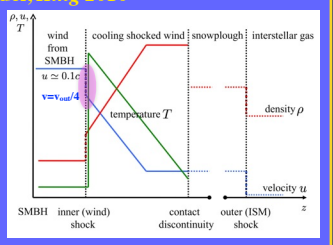
$\dot{M}_{out}$(C) ~ 0.26 Cf $M_\odot$ yr^{-1}
$\dot{E}$(C)~ 6 ×10^{43} Cf erg s^{-1}

$\frac{\dot{E}(C)}{L_{bol}}$ = 11% Cf

Energy rate sufficient to power feedback (*Hopkins & Elvis 2010*)

Shocked Outflow Model, *King 2010*





The accretion disc wind launched with velocity v_{out} suffers a shock with the circumnuclear gas that produces the effect of slowing the wind to a velocity v ~v_{out}/4

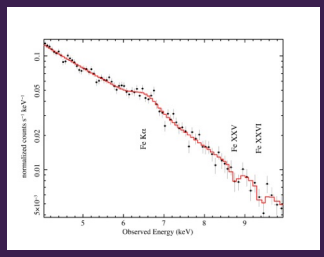
Our XMM CCD data show marginal evidence for two absorption lines consistent with ionized Fe K blue-shifted at v_{out}~0.34c

v(UFO RGS)~24,000-33,000 km s^{-1}

v(UFO CCD)~102,000 km s^{-1}

In close agreement with predictions of the shocked outflow model

EPIC pn data of IRAS17020+4544



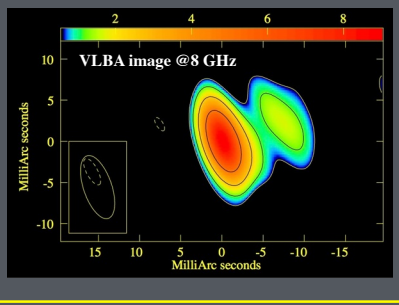
Gaussian absorption lines fitted to the power law continuum

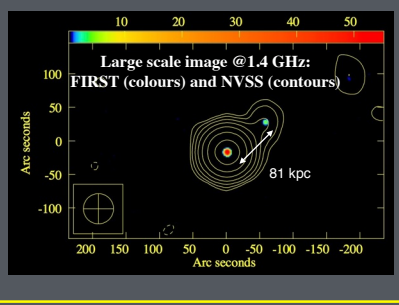
E=8.75± 0.13 keV
EW=49±43 eV

E=9.39± 0.10 keV
EW= 64±50 eV

If confirmed as Fe XXV and Fe XXVI v_{out}~ 0.34c

Radio Properties of IRAS17020+4544 (*M. Giroletti et al in prep.*)





$P_{1.4\ GHz} = 10^{24}$ W Hz^{-1}
$T_b = 10^8$ K

VLBA Observations in 2000 and 2014
Compact bright core plus a secondary fainter component at 1.2'
Steep spectral index indicates synchrotron spectrum (magnetic fields)
Elongated jetted structure/outflow at ~10 pc scale moving at v~ 0.1c

The presence of radio emission and jet structure suggests that the X-ray ultra fast wind may be magnetically driven or produced by the interaction of the radio jet with the surrounding material.

Possible connection with X-ray outflow under investigation

Take away messages

- Discovery of a fast outflowing wind with very rich ionization structure (O_{III} to O_{VIII}), multiple velocity components
- Possible higher velocity/ionization counterpart would confirm the shock outflow model
- Feedback in an undisturbed Seyfert Galaxy with moderate luminosity seems to defy current galaxies evolution models
- Radio properties consistent with presence of outflowing material
- XMM-Newton still provides new discoveries after 15 years !

Future Winds in IRAS17020+4544

- Chandra time granted for deep (250 ks) high-res spectroscopy of the low ionization UFO (LETG down to ~ 40 Angstrom)
- Additional Radio VLBI observations to investigate the extended radio structure (granted)
- Applied for HST/COS for first time UV spectroscopy of absorption troughs associated to X-ray ultra fast outflow
- Existing observations with Large Millimeter Telescope (LMT) reveal strong evidence for molecular outflows in IRAS17020+4544