On the presence of ultrafast outflows in the WAX sample of Seyfert galaxies

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\begin{abstract}

The study of winds in active galactic nuclei (AGNs) is of utmost importance as they may provide the long sought-after link between the central black hole and the host galaxy, establishing the AGN feedback. Recently, Laha et al. reported the X-ray analysis of a sample of 26 Seyferts observed with XMM–Newton, which are part of the so-called warm absorbers in X-rays (WAX) sample. They claim the non-detection of Fe K absorbers indicative of ultrafast outflows in four observations previously analysed by Tombesi et al. They mainly impute the Tombesi et al. detections to an improper modelling of the underlying continuum in the $E = 4$–10 keV band. We therefore re-address here the robustness of these detections and we find that the main reason for the claimed non-detections is likely due to their use of single events only spectra, which reduces the total counts by 40 per cent. Performing a re-analysis of the data in the whole $E = 0.3$–10 keV energy band using their models and spectra including also double events, we find that the blueshifted Fe K absorption lines are indeed detected at $> 99$ per cent. This work demonstrates the robustness of these detections in XMM–Newton even including complex model components such as reflection, relativistic lines and warm absorbers.

\textbf{Key words:} line: identification – galaxies: active – X-rays: galaxies.
\end{abstract}

\section{1 INTRODUCTION}

Mounting evidences for the presence of highly ionized, high-velocity outflows along the line of sight of bright active galactic nuclei (AGNs) have been obtained since the last decade. This Letter shows up preferentially in the X-ray spectra as blueshifted K-shell absorption lines from Fe XXV and Fe XXVI at energies $E \gtrsim 7$ keV of both high/low-z radio-quiet and radio-loud sources (e.g. Pounds et al. 2003b; Dadina et al. 2005; Markowitz, Reeves & Braito 2006; Braito et al. 2007; Cappi et al. 2009; Chartas et al. 2009; Tombesi et al. 2010a,b, 2011a,b, 2012b, 2013b; Ballo et al. 2011; Giustini et al. 2011; Patrick et al. 2012; Pounds & Vaughan 2012; Gofford et al. 2013; Reeves et al. 2014).

Often the blueshifts of these lines imply an outflow velocity higher than 10 000 km s\textsuperscript{-1}, in which cases the absorbers are indicated as ultrafast outflows (UFOs). This velocity threshold is arbitrary, being chosen only to initially differentiate with the slower ($v_{\text{out}} \simeq 100$–1000 km s\textsuperscript{-1}), less ionized warm absorbers (WAs) commonly detected in the soft X-rays. The location and kinetic power of the UFOs indicate that they could represent powerful accretion disc winds, capable of exerting a significant feedback on the surrounding environment (e.g. King & Pounds 2003; Tombesi et al. 2012a). Possible links between the UFOs and the WAs have been recently explored (Fukumura et al. 2010, 2014; Pounds & Vaughan 2012; Tombesi et al. 2013a; King & Pounds 2014). Recently Laha et al. (2014) reported the analysis of a sample of 26 Seyferts 1s observed with XMM–Newton, the so-called warm absorbers in X-rays (WAX) sample. The main objective of that work was to estimate the parameters of the WAs in these sources performing a combined RGS and EPIC-pn data analysis in the $E = 0.3$–10 keV band. Laha et al. (2014) also performed an eye-inspection of the residuals of their models in the $E = 6$–8.5 keV energy band for six sources with UFOs reported in Tombesi et al. (2010a, see their fig. A6) and, combined with other evidences from the literature, claimed that Fe K absorption lines are not present in these cases. Here, we consider a critical analysis of these statements for these six sources, namely Mrk 509, Ark 120, UGC 3973, NGC 4051, Mrk 766 and IC 4329A, and demonstrate the presence of UFOs in these data sets and discuss the reasons why they reached different conclusions.

\section{2 DATA ANALYSIS AND RESULTS}

The XMM–Newton EPIC-pn spectra were extracted following the method of Laha et al. (2014). We use the latest calibration files and

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software packages HEASOFT v. 6.15, SAS v. 13.5 and XSPEC+ v. 12.8.1 (as of 2014 April). Here, the inspection of the Fe K-band region is performed using both ratios and energy–intensity contour plots, as described in section 3.2 of Tombesi et al. (2010a). The neutral Fe Kα emission line and related reflection component are modelled with pexmon in XSPEC, as Laha et al. (2014). When indicated by Laha et al. (2014), relativistic broad lines are modelled with laor or diskline in XSPEC – assuming an outer radius of \( r_{\text{out}} = 400 r_g \) and an inner radius of \( r_n = 1.235 r_g \) and \( r_n = 10 r_g \), respectively. The WAs are modelled with an XSTAR table with turbulent velocity of 100 km s\(^{-1}\) (as Laha et al. 2014) and an ionizing continuum with a slope \( \Gamma \simeq 2 \), consistent with the average for Seyfert 1s (Tombesi et al. 2011b). Throughout, we consider the 1σ errors for one additional parameter, if not otherwise stated.

We note that Laha et al. (2014) extracted the spectra using only single events because this provides a slightly better energy resolution and they represent the bulk of events at \( E < 2 \) keV. While this choice could be seen as appropriate for their soft X-ray focused analysis, it causes a significant loss of counts with respect to considering both singles and doubles, about 40 per cent less in the 4–10 keV band.\(^1\) As shown below, this is in our opinion the main reason why Laha et al. (2014) did not report the detection of any Fe K absorption lines. We find that the lines are indeed present in the single events’ spectra with parameters consistent within the 1σ uncertainties. However, given the much lower signal-to-noise ratio, their significance is lower than 99 per cent in three out of four cases, namely Mrk 509 (96 per cent), Ark 120 (95 per cent) and IC 4329A (98.5 per cent).

The EPIC-pn data in Laha et al. (2014) are grouped to a minimum of 20 counts per energy bin and at most 5 energy bins per resolution element. We find this probably not to be the best choice when fitting the wide 0.3–10 keV band given the large difference in counts between low and high energies. In fact, the binning fixed to the energy resolution will give a higher statistical weight at those energy points with higher number of counts per bin, thus even small fluctuations in the soft X-rays can inflate the \( \chi^2 \) distribution. This effect is reduced allowing a more similar statistical weight for each data point, for instance just rebinning to a minimum of 25 counts per bin. The same best-fitting model can result in a higher \( \chi^2/\nu \) in the former case, as seen in several values reported in table 5 of Laha et al. (2014). Moreover, given that the F-test probability depends on \( \chi^2/\nu \), for the same best-fitting model and the same value of \( \Delta \chi^2/\Delta \nu \), the resultant probability is systematically lower in the former case. This effect is negligible considering a limited energy band, e.g. \( E = 4–10 \) keV (Tombesi et al. 2011b).

In the following, we will test the possible model dependence of the Fe K absorption lines using the EPIC-pn spectra (including both single and double events) and rebinning the data to a minimum of 25 counts per bin.

### 2.1 Mrk 509

Laha et al. (2014) reported the combined RGS and EPIC-pn analysis of one XMM–Newton observation of Mrk 509 performed in 2005 October (OBSID 0306090201). They claim that there are no Fe K absorption features in the 6–8.5 keV band after an eye-inspection of the residuals in their fig. A6. This is not consistent with the detection of an absorption line at the observed energy of \( E = 7.76 \) keV reported by Cappi et al. (2009) and Tombesi et al. (2010a).

\(^1\) [http://xmm2.esac.esa.int/docs/documents/CAL-TN-0018.pdf](http://xmm2.esac.esa.int/docs/documents/CAL-TN-0018.pdf)

### 2.2 Ark 120

Laha et al. (2014) analysed the spectrum of one XMM–Newton observation of Ark 120 (OBSID 0147190101). Tombesi et al. (2010a) reported the detection of a blueshifted Fe K absorption line at the observed energy of \( E = 8.89 \pm 0.03 \) keV. In their eye-inspection of the Fe K band in fig. A6, Laha et al. (2014) claim the non-detection of such feature. However, we note that this might simply be due to the fact that the feature is outside of the energy band considered of \( E = 6–8.5 \) keV.

Anyway, the broad-band model assumed by Laha et al. (2014) consists of a power-law continuum with \( \Gamma = 1.97 \), two blackbody components to model the soft excess with temperatures \( kT = 102 \) and 240 eV (see their table 5). They also include a soft X-ray emission line at the energy \( E = 0.554 \) keV and a pexmon reflection...
component with $R = 0.75$. They do not report a significant detection of a WA in this source (see their table 6). Finally, they also include a putative diskline with parameters $E = 6.9\text{ keV}$, $\beta = -3.8$, $i < 50^\circ$. In this case they implicitly assume a non-spinning black hole. We find again that this model can fit the data only for a very low pexmon iron abundance of $A_{\text{Fe}} = 0.40^{+0.04}_{-0.02}$ and a low inclination of the diskline of $i \approx 13^\circ$.

As we can see for the ratios and the contour plots in Fig. 1, the line at the observed energy of $E = 8.89\text{ keV}$ is indeed present. It has an intensity corresponding to about 20 per cent of the continuum. The line parameters are $E = 9.18 \pm 0.03\text{ keV}$ (rest frame), $\sigma = 0$ (unresolved), $I = (-6.5 \pm 1.7) \times 10^{-6} \text{ ph s}^{-1}\text{ cm}^{-2}$, $\text{EW} = -31^{+9}_{-6}\text{ eV}$. These values are consistent with those reported by Tombesi et al. (2010a) in their table A.2. The detection confidence level is 99.3 per cent ($\Delta \chi^2 / \Delta \nu = 13.8 / 2$). The fit statistics is $\chi^2 / \nu = 2449.6 / 1776$.

### 2.3 UGC 3973

Laha et al. (2014) considered one XMM–Newton observation of UGC 3973 (or Mrk 79) obtained in 2008 April (OBSID 0502091001). This observation was not in the sample of Tombesi et al. (2010a), who considered three observations obtained between 2006 and 2007. Tombesi et al. (2010a, 2011b) reported the detection of a blueshifted Fe K absorption line at $E = 7.63\text{ keV}$ indicative of a UFOs with velocity $v_{\text{out}} \approx 0.09c$ in the first observation (OBSID 0400070201). The fact that Laha et al. (2014) did not observe an intense Fe K absorption line in their spectrum could be due to...
variability of the absorber and/or to the lower statistics of this fainter observation (also limited by the use of single events only).

2.4 NGC 4051

Blueshifted Fe K absorption lines have been reported by many authors in this source using both XMM--Newton and Suzaku. Tombesi et al. (2010a, 2011b) analysed the first two XMM--Newton observations of this source (OBSID 0109141401 and 0157560101) and reported highly ionized Fe K outflows with velocities of $v_{\text{out}} \simeq 11,000 \text{ km s}^{-1}$ and $v_{\text{out}} \simeq 0.2c$, respectively. We note that Fe K outflows with velocities of $\sim 6,000 \text{ km s}^{-1}$ and $\sim 0.1c$ were reported also by several other authors using Chandra, XMM--Newton and Suzaku data (Lobban et al. 2011; Patrick et al. 2012; Pounds & Vaughan 2012; Gofford et al. 2013).

Laha et al. (2014) considered the first XMM--Newton observation of NGC 4051 (OBSID 0109141401) in their WAX sample. From an eye-inspection of the $E = 6.8 \pm 5.5 \text{ keV}$ residuals in their fig. A6, they claim that the absorption line at the observed energy of $E \simeq 7.06 \text{ keV}$ reported by Tombesi et al. (2010a) is not detected. In order to check whether this was due to their broad-band modelling or to an inadequate analysis of the Fe K-band data, we re-analyse the EPIC-pn spectrum using their model. We note that this feature is detectable also in the single events’ spectrum at >99 per cent.

They consider a rather steep power-law continuum with $\Gamma = 2.35$, a blackbody component with $kT = 101 \text{ eV}$ to model the soft excess and a pexmon neutral reflection component with a very high reflection fraction $R \simeq 5$ (see their table 5). In the soft X-rays, they consider two emission lines at $E = 0.561$ and $0.597 \text{ keV}$. We include two WAs. The first with $\log E = 0.28 \text{ erg s}^{-1} \text{ cm}$, $\log N_{\text{HI}} = 20.43 \text{ cm}^{-2}$ and $v_{\text{out}} = -600 \text{ km s}^{-1}$. The second with $\log E = 2.87 \text{ erg s}^{-1} \text{ cm}$, $\log N_{\text{HI}} = 22.39 \text{ cm}^{-2}$ and $v_{\text{out}} = -688 \text{ km s}^{-1}$ (see their table 6).

Finally, they also include a putative broad disc line using the laor model. They require extreme parameters, with a line energy of $E = 7 \text{ keV}$, large equivalent width of $EW = 461 \text{ eV}$, high-emissivity profile of 7.6, and inclination of $i < 41^\circ$ (see their table 7). The use of laor, which assumes a maximally spinning black hole, is not justified. Moreover, such an extreme broad line has never been reported before (e.g. Nandra et al. 2007; Patrick et al. 2012).

We find that in order to provide a sufficient representation of the spectrum this model requires again a very low pexmon iron abundance of $A_{\text{Fe}} = 0.19 \pm 0.01$. From the spectral ratios and the contour plots in Fig. 1, we note that an absorption feature at $E \simeq 7.06 \text{ keV}$ is indeed present in the data. In fact, the inclusion of an absorption line gives the same parameters as those reported in table A.2 of Tombesi et al. (2010a, i.e. $E = 7.04^{+0.03}_{-0.02} \text{ keV}$ (rest frame), $\sigma = 0 \text{ eV}$ (unresolved), $I = (-5.3 \pm 1.3) \times 10^{-6} \text{ ph s}^{-1} \text{ cm}^{-2}$ and $EW = -28 \pm 7 \text{ eV}$. The line is required at 99.8 per cent ($\Delta \chi^2/\Delta v = 15/2$). The fit statistics is $\chi^2/\nu = 1857.2/1593$.

2.5 Mrk 766

This source is well known to show complex and highly variable absorption in the Fe K band due to outflowing winds with velocities of the order of $v_{\text{out}} \simeq 10,000\text{–}20,000 \text{ km s}^{-1}$ from XMM--Newton and Suzaku data (e.g. Pounds et al. 2003a; Miller et al. 2007; Turner et al. 2007; Risaliti et al. 2011; Patrick et al. 2012; Gofford et al. 2013).

Laha et al. (2014) report the non-detection of Fe K absorption lines in an XMM--Newton observation performed in 2001 (OBSID 0109141301). We note that Tombesi et al. (2010a, 2011b) also did no report a detection in this case. However, Tombesi et al. (2010a) analysed eight XMM--Newton observations of Mrk 766 and reported Fe K absorption lines indicative of UFOs with a velocity of $v_{\text{out}} \simeq 20,000 \text{ km s}^{-1}$. In two cases (OBSID 0304030301 and 0304030501), given the high X-ray flux variability and the highly ionized absorbers in this source, a thorough inspection of the Fe K band would require a time-resolved spectral analysis (e.g. Miller et al. 2007; Turner et al. 2007; Risaliti et al. 2011).

2.6 IC 4329A

Laha et al. (2014) report the analysis of the XMM--Newton observation of IC 4329A (OBSID 0147440101) performed in 2003. They claim the non-detection of an absorption line at the observed energy of $E = 7.57 \pm 0.03 \text{ keV}$ previously reported by Tombesi et al. (2010a). We note that this absorption line was initially reported by Markowitz et al. (2006), who performed a detailed broad-band analysis of the same XMM--Newton data set.

We re-analyse the data applying Laha et al. (2014) model. We consider a neutral absorbed ($N_{\text{HI}} = 3.8 \times 10^{21} \text{ cm}^{-2}$) power-law continuum with $\Gamma \sim 1.8$ and two blackbody components with temperatures $kT = 46$ and $286 \text{ eV}$ to model the soft excess (see their table 5). We consider also a pexmon component with $R = 1.67$ and an emission line at $E = 6.87 \text{ keV}$. We include two soft X-ray emission lines at $E = 0.528$ and $0.649 \text{ keV}$ and three WAs. The first with $\log E = -0.58 \text{ erg s}^{-1} \text{ cm}$, $\log N_{\text{HI}} = 20.96 \text{ cm}^{-2}$ and $v_{\text{out}} = -1020 \text{ km s}^{-1}$. The second with $\log E = 1.87 \text{ erg s}^{-1} \text{ cm}$, $\log N_{\text{HI}} = 20.54 \text{ cm}^{-2}$ and $v_{\text{out}} = -660 \text{ km s}^{-1}$. The third with $\log E = 3.33 \text{ erg s}^{-1} \text{ cm}$, $\log N_{\text{HI}} = 21.27 \text{ cm}^{-2}$ and $v_{\text{out}} = -990 \text{ km s}^{-1}$ (see their tables 5 and 6). Finally, we include also a putative broad line, parameterized with diskline, with $E = 6.3 \text{ keV}$, $\beta = -2.19$ and $i = 30^\circ$. This implicitly assumes a non-spinning black hole. The fit requires a pexmon iron abundance of $A_{\text{Fe}} = 0.95^{+0.25}_{-0.50}$.

From the ratios and the contour plots in Fig. 1 we note the presence of an absorption feature at the observed energy of $E \simeq 7.57 \pm 0.03 \text{ keV}$. Indeed, this absorption line with rest-frame energy $E = 7.70^{+0.02}_{-0.03} \text{ keV}$, intensity $I = (\pm 11.8 \pm 2.5) \times 10^{-6} \text{ ph s}^{-1} \text{ cm}^{-2}$ and $EW = -15.4^{+3.4}_{-2.3} \text{ eV}$ is required at 99.99 per cent ($\Delta \chi^2/\Delta v = 20.4/2$). The fit statistics is $\chi^2/\nu = 2200.3/1925$. The absorption line parameters are equivalent to those reported by Markowitz et al. (2006) and Tombesi et al. (2010a).

3 DISCUSSION AND CONCLUSIONS

We report a critical examination of the claims of Laha et al. (2014) regarding the absence of UFO detections in six XMM--Newton EPIC-pn observations of six sources of their WAX sample. Four of these were previously analysed by Tombesi et al. (2010a). The non-detection is mainly imputed to an improper modelling of the $E = 4\text{–}10 \text{ keV}$ band. Here, we show a re-analysis of the data following their procedure and using their models in the whole $E = 0.3\text{–}10 \text{ keV}$ interval.

The main reason why Laha et al. (2014) did not find any Fe K absorption lines is likely due to their selection of only single events’ spectra, thus losing 40 per cent of the total counts. In fact, we find that the lines are present in the single events’ spectra, although with a significance slightly lower than 99 per cent in 3 out of 4 cases. In NGC 4051, the line is present at >99 per cent also in the single events’ spectrum. Using the single and double events spectra, we find that the absorption lines are indeed present at >99 per cent in the four cases considered (Mrk 509, NGC 4051, IC 4329A and Ark 120), with parameters equivalent to those previously reported by Tombesi et al. (2010a). Some of these lines might have also been
missed in the eye-inspection of the residuals in fig. A6 by Laha et al. (2014).

Most of the soft X-ray WAs in Laha et al. (2014) have low column densities ($N_H \lesssim 10^{21}$ cm$^{-2}$), implying a very limited influence in the Fe $K$ band. In fact, we checked that the Fe $K$ absorption lines are present both with and without their inclusion.

Overall, this re-analysis shows the robustness of the detection of the Fe $K$ absorption lines in the broad-band XMM–Newton $E = 0.3$–$10$ keV spectra using complex model components such as reflection, relativistic lines and WAs. This is consistent with the more detailed Suzaku and Swift BAT 0.6–100 keV spectral analyses of Patrick et al. (2012) and Gofford et al. (2013).

We warn that although the models assumed by Laha et al. (2014) provide an overall good representation of the data, they might be affected by systematics. For instance, their models often require a steep power law, very high neutral reflection fraction, very low iron abundance and very broad disc lines. Many of these parameters are not consistent with previous studies (e.g. Dadina 2007; Nandra et al. 2007; Patrick et al. 2012; Pounds & Vaughan 2012; Gofford et al. 2013). Moreover, a thorough constraint of the continuum and reflection requires the use of instruments with sensitivity above 10 keV (e.g. Patrick et al. 2012; Gofford et al. 2013).

A better modelling and characterization of the Fe $K$ absorption lines will be provided by the simultaneous use of the calorimeter and broad-band coverage offered by ASTRO-H (Takahashi et al. 2012).

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REFERENCES

Ballo L., Braito V., Reeves J. N., Sambruna R. M., Tombesi F., 2011, MNRAS, 418, 2367
Braito V. et al., 2007, ApJ, 670, 978
Cappi M. et al., 2009, A&A, 504, 401
Chartas G., Saez C., Brandt W. N., Giustini M., Garmire G. P., 2009, ApJ, 706, 644
Dadina M., 2007, A&A, 461, 1209
Dadina M., Cappi M., Malaguti G., Ponti G., de Rosa A., 2005, A&A, 442, 461
Fukumura K., Kazanas D., Contopoulos I., Behar E., 2010, ApJ, 715, 636
Fukumura K., Tombesi F., Kazanas D., Shrader C., Behar E., Contopoulos I., 2014, ApJ, 780, 120
Giustini M. et al., 2011, A&A, 536, A49
Gofford J., Reeves J. N., Tombesi F., Braito V., Turner T. J., Miller L., Cappi Massimo, 2013, MNRAS, 430, 60
King A. R., Pounds K. A., 2003, MNRAS, 345, 657
King A. R., Pounds K. A., 2014, MNRAS, 437, L81
Laha S., Guainazzi M., Dewangan G. C., Chakravorty S., Kembhavi A. K., 2014, MNRAS, 441, 2613
Lobban A. P., Reeves J. N., Miller L., Turner T. J., Braito V., Kraemer S. B., Crenshaw D. M., 2011, MNRAS, 414, 1965
Markowitz A., Reeves J. N., Braito V., 2006, ApJ, 646, 783
Miller L., Turner T. J., Reeves J. N., George I. M., Kraemer S. B., Wingert B., 2007, A&A, 463, 131
Nandra K., O’Neill P. M., George I. M., Reeves J. N., 2007, MNRAS, 382, 194
Patrick A. R., Reeves J. N., Porquet D., Markowitz A. G., Braito V., Lobban A. P., 2012, MNRAS, 426, 2522
Petrucci P.-O. et al., 2013, A&A, 549, A73
Ponti G. et al., 2013, A&A, 549, A72
Pounds K. A., Vaughan S., 2012, MNRAS, 423, 165
Pounds K. A., Reeves J. N., Page K. L., Wynn G. A., O’Brien P. T., 2003a, MNRAS, 342, 1147
Pounds K. A., Reeves J. N., King A. R., Page K. L., O’Brien P. T., Turner M. J. L., 2003b, MNRAS, 345, 705
Reeves J. N. et al., 2014, ApJ, 780, 45
Risaliti G. et al., 2011, MNRAS, 410, 1027
Tombesi F., Cappi M., Reeves J. N., Palumbo G. G. C., Yaqoob T., Braito V., Dadina M., 2010a, A&A, 521, A57
Tombesi F., Sambruna R. M., Reeves J. N., Braito V., Ballo L., Gofford J., Cappi M., Mushotzky R. F., 2010b, ApJ, 719, 700
Tombesi F., Sambruna R. M., Reeves J. N., Reynolds C. S., Braito V., 2011a, MNRAS, 418, L89
Tombesi F., Cappi M., Reeves J. N., Palumbo G. G. C., Braito V., Dadina M., 2011b, ApJ, 742, 44
Tombesi F., Cappi M., Reeves J. N., Braito V., 2012a, MNRAS, 422, L1
Tombesi F., Sambruna R. M., Marscher A. P., Jorstad S. G., Reynolds C. S., Markowitz A., 2012b, MNRAS, 424, 754
Takahashi T. et al., 2012, in Takahashi T., Murray S. S., den Herder J.-W. A., eds, Proc. SPIE Conf. Ser. Vol. 8443, Space Telescopes and Instrumentation 2012: Ultraviolet to Gamma Ray. SPIE, Bellingham, p. 1
Tombesi F., Cappi M., Reeves J. N., Nemmen R. S., Braito V., Gaspari M., Reynolds C. S., 2013a, MNRAS, 430, 1102
Tombesi F., Reeves J. N., Reynolds C. S., Garcia J., Lohfink A., 2013b, MNRAS, 434, 2707
Turner T. J., Miller L., Reeves J. N., Kraemer S. B., 2007, A&A, 475, 121

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