We present the results of optical spectroscopy for 19 quasar candidates at photometric redshifts $z_{\text{phot}} \gtrsim 3$, 18 of which enter into the Khorunzhev et al. (2016) catalog (K16). This is a catalog of quasar candidates and known type 1 quasars selected among the X-ray sources of the 3XMM-DR4 catalog of the XMM-Newton serendipitous survey. We have performed spectroscopy for a quasi-random sample of new candidates at the 1.6-m AZT-33IK telescope of the Sayan Solar Observatory and the 6-m BTA telescope of the Special Astrophysical Observatory. The spectra at AZT-33IK were taken with the new low- and medium-resolution ADAM spectrograph that was produced and installed on the telescope in 2015. Fourteen of the 18 candidates actually have turned out to be quasars; 10 of them are at spectroscopic redshifts $z_{\text{spec}} > 3$. The high purity of the sample of new candidates suggests that the purity of the entire K16 catalog of quasars is probably 70–80%. One of the most distant $(z_{\text{spec}} = 5.08)$ optically bright $(i' \lesssim 21)$ quasars ever detected in X-ray surveys has been discovered.

Keywords: active galactic nuclei, X-ray surveys, photometric redshifts, spectroscopy, XMM-Newton.

1. INTRODUCTION

Searching for quasars at $z \gtrsim 3$ is one of the most important elements of studying the growth history of supermassive black holes and the evolution of massive galaxies in the Universe. To construct the X-ray luminosity function for quasars at $z \gtrsim 3$ requires collecting a large and well-defined X-ray sample of such objects with fluxes $\lesssim 10^{-14}$ erg s$^{-1}$ cm$^{-2}$ (0.5–2 keV).

The number of sources in the deep XMM-Newton and Chandra X-ray surveys (typical fluxes $\lesssim 10^{-15}$ erg/s/cm$^2$ in the 0.5–2 keV energy band and areas of ~1 sq. deg.) turns out to be insufficient to trace in detail the evolution of active galactic nuclei (Civano et al., 2012; Vito et al., 2014). Through the addition of data from the less deep XBootes, XMM-XXL X-ray surveys (typical 0.5–2 keV fluxes $\sim 10^{-14}$ erg/s/cm$^2$) the sky coverage area increases by a factor of ~10 (Ueda et al., 2014; Aird et al., 2015; Georgakakis et al., 2015). In their recent Kalfountzou et al. (2014) paper constructed the X-ray luminosity function for quasars at $z > 3$ in a field $\approx 33$ sq. deg. The survey of such a field was composed of the archival data from individual pointings of the Chandra satellite over the entire time of its operation. (Kalfountzou et al., 2014) managed to exclude some models of the luminosity function using the survey data, but the size of this sample turns out to be insufficient to investigate the properties of the population of bright (luminosities $> 5 \times 10^{44}$ erg/s) and distant ($z > 3.5$) quasars.

The data from the XMM-Newton X-ray telescope accumulated over 15 years represent a serendipitous X-ray sky survey (Watson et al., 2009) with a total area of ~800 sq. deg. and a sensitivity $\approx 5 \times 10^{-15}$ ergs$^{-1}$ cm$^{-2}$ (the 3XMM-DR4 version (Watson et al., 2009). A sample of quasars at $z > 3$ selected by their X-ray emission that exceeds the existing samples of Kalfountzou et al. (2014); Georgakakis et al. (2015) by several times can be obtained from the data of this survey.

Previously (Khorunzhev et al., 2016), we made an attempt to find new sources and to obtain a more...
Fig. 1: Spectra of the distant quasar 3XMM J125329.4+305539 (z spec = 5.08) taken at the 1.6-m AZT-33IK telescope (left) and the 6-m BTA telescope (right). The neighboring spectral channels are binned by two along the wavelength axis.

A quasi-random spectroscopic survey of 18 quasar candidates from the K16 catalog that previously had no spectroscopic redshifts has been conducted at the AZT-33IK telescope (Kamus et al. 2002) equipped with the low- and medium-resolution ADAM spectrograph (Afanasev et al. 2016; Burenin et al. 2016).

The AZT-33IK telescope is located at the Sayan Solar Observatory of the Institute of Solar–Terrestrial Physics, the Siberian branch of the Russian Academy of Sciences, and has a primary mirror diameter of 1.6 m. The ADAM spectrograph was produced at the Special Astrophysical Observatory and was installed on AZT-33IK in 2015. The main structural components of the spectrograph are: Andor Newton 920 array with an efficiency of ~90% in the range
from 4000 to 8500Å and a set of dispersive elements (volume phase holographic gratings). The quantum efficiency of the entire system (the telescope mirror, the spectrograph, the grating, and the CCD array) reaches 50% (Burenin et al., 2016).

The target objects of the K16 sample are quasars with broad emission lines. The typical apparent magnitude of the objects is $i' \sim 20.5$. The exposure time was chosen to be sufficient for the bright emission lines from which the quasar redshift could be determined to manifest themselves. This allows the spectra for quite a few sources to be taken with a small telescope. Spectra with a higher signal-to-noise ratio in continuum are required to determine a small telescope. Spectra with a higher signal-to-noise ratio in continuum are required to determine redshift and type of sources without bright lines. Repeated observations with a longer exposure time or at larger telescopes are needed for this purpose.

The properties of the K16 sample change significantly with increasing redshift: the number of objects drops exponentially; the X-ray and optical fluxes become fainter. On average, the K16 objects are at $z_{\text{spec}} \sim 3$ and have magnitudes $i' \sim 20.5$. There are only a few dozen candidates at $z_{\text{phot}} > 4$ with magnitudes $i' > 20.5$ in the K16 catalog. We selected the sources for our observations almost randomly within two ranges: $2.75 < z_{\text{phot}} < 4$ and $z_{\text{phot}} \geq 4$. However, in the range $2.75 \leq z_{\text{phot}} < 4$ we preferentially observed bright candidates with $i' < 20$. These peculiarities of the selection of objects for our spectroscopic program should be taken into account when formulating the conclusions about the purity of the entire K16 catalog of quasars.

The quasar candidates were observed in dark time (the lunar phase is less than 0.3) and at a mean seeing better than 2-arcsec. Under such conditions, a one-hour exposure time is sufficient for the detection of emission lines in the spectra of quasars with magnitudes $i' = 20.5$. For our observations we used a 2-arcsec-wide slit. The objects at $z_{\text{phot}} < 3.5, 3.5 < z_{\text{phot}} < 4.5, 4.5 < z_{\text{phot}}$ were observed with the VPHG600G (the range is 3700–7340Å, the resolution is 8.8Å), VPHG300 (the range is 3900–10500Å, the resolution is 13.8Å), and VPHG600R (the range is 6520–10100Å, the resolution is 7.3Å) gratings, respectively. The above resolutions were achieved for the 2-arcsec-wide slit. We chose such a grating that the presumed position of the Lyα line was near the peak of its diffraction efficiency. The data were reduced with the standard IRAF software.

3. RESULTS

The list of objects is given in Table 1 (end of this paper, their spectra are shown below in Fig. 3). The shape of the spectra was corrected using the observations of spectrophotometric standards from the list by Massey et al. (1988). Fourteen of the 18 are quasars; 10 of them are quasars at $z_{\text{spec}} > 3$. Their redshifts were determined from the positions of the peaks of broad lines in the spectrum. The types of the remaining objects are difficult to determine, because there are no bright emission lines in their spectra.

The accuracy of the redshift for distant objects depends on the spectrograph resolution as $(1 + z) \times \frac{\Delta \lambda}{\lambda}$ and is approximately 0.01 for low-resolution spectra. Therefore, the spectroscopic redshifts for the objects are given to the second decimal place. The shape and positions of broad lines are known to be closely related to the processes occurring near a black hole. The redshift determined from broad lines can slightly differ from $z_{\text{spec}}$ of the host galaxy. The redshifts in the spectra where only the Lyα line is seen should be treated with caution. Its shape can be severely distorted by absorption and, consequently, the position of its peak can be determined incorrectly. Such objects are marked by the quality flag (QF) = 1 in Table 1.

The spectroscopic sample of 18 “randomly” selected objects has a median 0.5-2 keV X-ray flux $\sim 5 \times 10^{-15}$ erg/s/cm². This value coincides with the median X-ray flux of the K16 sources. Among the selected objects there are no bright quasars with strong emission lines at $z_{\text{spec}} > 3$ with 0.5-2 keV fluxes $> 10^{-14}$ erg/s/cm². The median apparent magnitude is $i' = 19.9$, which is brighter than the mean value for the K16 by 0.5 magnitude. Thus, the sample of 18 sources may be deemed representative in X-ray flux for the K16, but not in optical flux.

3.1. The Quasar 3XMM J125329.4+305539 at $z = 5.08$

The distant X-ray quasar 3XMM J125329.4+305539 at $z_{\text{spec}} = 5.08$ and with an apparent magnitude $i' = 21$ was discovered and confirmed at the AZT-33IK and BTA telescopes. The AZT-33IK and BTA spectra are shown in Fig. 1.

The first spectrum of this object was taken at the AZT-33IK telescope with the ADAM spectrograph with an exposure time of 1.5 h. From the spectrum we managed to determine that the source is a distant quasar and to measure its redshift $z_{\text{spec}} = 5.1$. Telescopes with a larger diameter

http://iraf.noao.edu
are usually required to take the spectra of such sources. However, as can be seen from our results (see Fig. 1), using the new spectrograph with a high quantum efficiency in the near infrared at the 1.6-m AZT-33IK telescope, we can take the spectra of faint objects (down to $i' \approx 21$), and determine their types and redshifts.

To improve the spectroscopic redshift, we took a spectrum with a higher signal-to-noise ratio and a resolution of 18Å at the 6-m BTA telescope using the SCORPIO spectrograph (Afanasiev & Moiseev 2005) with an exposure time of 0.5 h. The redshift $z_{\text{spec}} = 5.08 \pm 0.01$ was determined by fitting the spectrum by the template of a type I quasar (Vanden Berk et al., 2001) into which the interstellar absorption by neutral hydrogen was introduced (Madau, 1995). The error of the template position is underestimated, because the error was introduced (Madau, 1995). The error of the interstellar absorption by neutral hydrogen was introduced (Madau, 1995). The error of the photometric redshift of the object in the K16 catalog; $z_{\text{spec}}$ is the spectroscopic redshift; $i'$ is the apparent magnitude in the SDSS $i'$ band; $F_{-14}$ is the 0.5–2 keV X-ray flux (erg/s/cm²) normalized to 10$^{-14}$, $L_{0.5–2}$ is the common logarithm of the X-ray luminosity (erg/s in 0.5–2 keV in the observer’s frame).

Therefore, 3XMM J004054.6–091527 is no longer considered as a quasar at $z_{\text{spec}} > 5.0$.

Thus, the object 3XMM J125329.4+305539 investigated by us is one of the brightest and most distant X-ray quasars at $z_{\text{spec}} > 5.0$ suitable for constructing the X-ray luminosity function at such redshifts. The redshifts, magnitudes, and X-ray fluxes of 3XMM J125329.4+305539 and the other three distant quasars listed above are given in Table 2. Note that there are also even more distant quasars in the 3XMM-DR4 catalog, but they were target sources for pointing the X-ray telescope (after their discovery in the optical band) and, therefore, cannot be used in constructing the X-ray luminosity function.

### 3.2. Remarks on Individual Objects

3XMM J025459.8+192343. This source ($z_{\text{spec}} = 2.81$) does not enter into the published K16 catalog, but, nevertheless, it was included in Table 1. Its spectrum was taken on the first nights of ADAM operation, when it was a candidate in the intermediate version of K16. We thought that the photometric redshift of the source was $z_{\text{phot}} = 2.6$, and it could theoretically be at $z_{\text{spec}} > 3$. This source enters into the catalog of quasar candidates by (Richards et al., 2015), where its best photometric redshift estimate is 3.295.

3XMM J062923.4+634935. There is a set of narrow absorption lines in the spectrum of this quasar ($z_{\text{spec}} = 2.88$). We assume that the most distinct lines are $\lambda_{\text{H}$\beta = 5696Å, $\lambda_{\text{MgI}=5175 = 6077Å, and $\lambda_{\text{NaI}=5891 = 6895Å. A cloud of intergalactic gas that gives such a line structure probably lies on the line of sight between us and the object (at $z_{\text{spec}} \approx 0.17$).

3XMM J103901.4+643335. This is a distant quasar at $z_{\text{spec}} = 4.08$. It is located in the region of the overlap between the XMM-Newton and

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**Table 2.** Properties of the selected X-ray quasars at $z_{\text{spec}} > 5$.

| Name (XMM)                  | $z_{\text{phot}}$ | $z_{\text{spec}}$ | $i'$   | $F_{-14}$ | $L_{0.5–2}$ |
|----------------------------|-------------------|-------------------|-------|----------|------------|
| J011544.8–001513           | 0.61              | 5.10              | 21.4  | 0.19     | 44.7       |
| J022112.5–034251           | 4.74              | 5.01              | 19.3  | 0.61     | 45.2       |
| J125329.4+305539           | 4.64              | 5.08              | 20.9  | 0.15     | 44.6       |
| J221643.9+001346           | 4.91              | 5.01              | 20.3  | 0.22     | 44.8       |

Note. $z_{\text{spec}}$ is the photometric redshift of the object in the K16 catalog; $z_{\text{spec}}$ is the spectroscopic redshift; $i'$ is the apparent magnitude in the SDSS $i'$ band; $F_{-14}$ is the 0.5–2 keV X-ray flux (erg/s/cm²) normalized to $10^{-14}$; $L_{0.5–2}$ is the common logarithm of the X-ray luminosity (erg/s in 0.5–2 keV in the observer’s frame).
Chandra surveys. Both telescope detected an X-ray flux from this source. The source was first reported as a quasar candidate in the K16 with $z_{\text{phot}} = 4.01$. There are only a few dozen known X-ray quasars at $z_{\text{spec}} \sim 4$. Therefore, the confirmation of this source has a high significance for studying the the population of quasars at such redshifts.

3XMM J131213.0+352347. This source has $z_{\text{phot}} = 4.92$. Feature characteristic of M-type stars are seen against the background of big noise in the spectrum.

Additional Remarks to the K16 Catalog

After the publication of the K16 catalog, having additionally browsed the literature, we found that two X-ray sources, 3XMM J122004.8+291304 and 3XMM J172014.1+264712, were erroneously included in the K16 catalog as quasar candidates. These X-ray sources turned out to be objects of the nearby Universe.

3XMM J122004.8+291304. This is a globular cluster in the halo of the nearby galaxy NGC 4278 (NGC 4278-X30 or CXO J122005.011+291304.73 (Li, 2011; Usher et al., 2012)).

3XMM J172014.1+264712. The source is the cluster galaxy RX J1720.1+2638 at $z = 0.338$ (Owers et al., 2011).

This information is included in Table 1.

3.4. Purity of the Quasi-Random Spectroscopic Sample and the K16 Catalog

We determined the spectroscopic redshifts of the 18 quasar candidates selected quasi-randomly from the K16 catalog. Let us estimate the purity of this sample in wide ranges of photometric redshifts: $2.75 \leq z_{\text{phot}} < 4$, $4 \leq z_{\text{phot}} < 5$, $5 \leq z_{\text{phot}} < 5.5$. By the purity we mean the ratio of the number of true quasars ($|z_{\text{phot}} - z_{\text{spec}}|/(1 + z_{\text{spec}}) < 0.2$) to the number of all objects with the available spectra. The condition $|z_{\text{phot}} - z_{\text{spec}}|/(1 + z_{\text{spec}}) < 0.2$ is introduced to take into account the scatter of $z_{\text{phot}}$ relative to $z_{\text{spec}}$. A value of 0.2 roughly corresponds to three standard deviations of $z_{\text{phot}}$ relative to $z_{\text{spec}}$ for all of the known and spectroscopically confirmed quasars from the complete K16 catalog (see Khorunzhev et al. (2016)). The purity of the spectroscopic sample of 18 objects calculated in this way is shown in Fig. 2 (circles). For comparison, the arrows in Fig. 2 indicate the lower limit for the purity of the entire K16 catalog (without the AZT-33IK observations). This limit was deduced as the ratio of the number of true quasars with known spectroscopic redshifts and $|z_{\text{phot}} - z_{\text{spec}}|/(1 + z_{\text{spec}}) < 0.2$ to the total number of objects in the catalog. Recall that the candidate sources without spectroscopic redshifts accounted for about 40% of the K16 objects.

Since the purity of the K16 catalog was initially higher than 50% and since more than half of the 18 objects with optical AZT-33IK spectroscopy turned out to be quasars at $z_{\text{spec}} > 3$, we can draw the preliminary conclusion that the true purity of the K16 catalog of candidates for distant quasars is 70–80%. This conclusion is yet to be refined, because the sample for our observations at the AZT-33IK telescope was not absolutely random and consisted of relatively bright (for the K16) objects.

4. CONCLUSIONS

In this paper we showed that the purity of the quasi-random sample of 18 quasar candidates from the K16 catalog exceeds 50%. Strictly speaking, this is true only for optically bright sources, $i' \lesssim 20$. We are going to continue the spectroscopy of candidates from the K16 sample with the ADAM spectrograph at the AZT-33IK telescope. However, a telescope with a larger diameter will be required to check the bulk of the K16 objects ($i' \sim 20.5$, $z_{\text{phot}} \sim 3$). It is expected that faint and distant ($z_{\text{phot}} > 4$) objects will be observed at the 6-m BTA telescope.

Our spectroscopy of the selected X-ray candidates for distant quasars detected by an improved selection method based on publicly accessible SDSS and WISE photometric data
confirmed that more quasars than in the available catalogs could be found (Richards et al. 2015; DiPompeo et al., 2015). The discovery of one of the most distant selected X-ray quasars (3XMM J125329.4+305539 at $z_{\text{spec}} = 5.08$) proves this convincingly.

Apart from the new quasar 3XMM J125329.4+305539 the K16 catalog contains three more optically bright ($i' < 21$) quasars at $z_{\text{spec}} > 5$. The X-ray fluxes and luminosities of these four objects in the 0.5–2 keV energy band exceed $1.5 \times 10^{-15}$ erg/s/cm$^2$ and $4 \times 10^{44}$ erg/s, respectively. About 50 sq. deg. is covered with this or better sensitivity in the regions of the overlap between 3XMM-DR4 and SDSS (see Fig. 9 in Khorunzhev et al. 2016). Therefore, it is interesting to note that approximately the same ($\sim 3 \times 10^{-15}$ erg/s/cm$^2$) limiting sensitivity must be achieved in the planned four-year sky survey by the eROSITA telescope onboard the SRG observatory near the ecliptic poles in a field of about 150 sq. deg. (Merloni et al., 2012). Consequently, it will be possible to detect several new optically bright quasars at $z > 5$ with an X-ray luminosity higher than $\sim 10^{45}$ erg/s in these fields. At the same time, the total number of quasars at $z > 5$ discovered by the eROSITA telescope near the ecliptic poles may turn out to be much greater (tens or even hundreds; Kolodzig et al. 2013), but most of them will most likely be fainter than the SDSS sensitivity threshold. Deeper optical surveys, for example, PanSTARRS (Hodapp et al. 2004) and the sky surveys conducted by the Hyper Suprime-Cam (Miyazaki et al., 2012) at the 8-m Subaru telescope, will be required for their identification. Note also that the $K16$ catalog has no X-ray quasars or quasar candidates at $z > 5$ with fluxes higher than $10^{-14}$ erg/s/cm$^2$ (corresponds to the mean all-sky sensitivity of the four-year eROSITA survey), i.e., a 0.5–2 keV luminosity higher than $\sim 3 \times 10^{45}$ erg/s in a field of $\approx 250$ кв. град. This is consistent with the predictions made by Georgakakis et al. (2015) based on their model of the X-ray luminosity function for quasars at $3 < z < 5$. Consequently, one might expect no more than $\sim 500$ optically bright quasars at $z > 5$ with a luminosity higher than $3 \times 10^{45}$ erg/s (0.5–2 keV) to be found in the eROSITA survey.

Our quasar spectra demonstrate the unique capabilities of the new ADAM spectrograph installed on the AZT-33IK telescope at the Sayan Solar Observatory. The ADAM spectrograph allows the spectra of objects with an apparent magnitude $R \sim 19.5$ to be taken with an exposure time of 30 min. If necessary and under good weather conditions, a magnitude $I \sim 21$ can be reached with an exposure time of two hours. The ADAM spectrograph is planned to be one of the instruments for the optical support of the SRG project (Merloni et al., 2012; Pavlinsky et al., 2011).

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СПИСОК ЛИТЕРАТУРЫ

1. V. Afanasiev, A. Moiseev, Astron. Letters 31, 193 (2005). [В. Афанасьев и А. Моисеев, Astron. Letters 31, 214 (2005).]
2. V.L. Afanasiev, S.N. Dodonov, V.R. Amirkhanyan, A.V. Moiseev, Astrophysical Bulletin 71, 479 (2016) [В. Афанасьев, С. Додонов, В. Амирхонян, А. Моисеев. Астрофизический Бюллетень, т. 71, с. 514, 2016]
3. J. Aird, A. Coil, A. Georgakakis, K. Nandra, G. Barro, P. Perez-Gonzalez, MNRAS. 451, 1892 (2015).
4. S. Alam, F. Albareti, C. Prieto, F. Anders, S. Anderson, B. Andrews, et al., Astrophys. J. Suppl. Ser. 219, 12 (2015).
5. S. Anderson, X. Fan, G. Richards, D. Schneider, M. Strauss, D. Vanden Berk, et al., Astron. J. 122, 503 (2001).
6. G. Brammer, P. van Dokkum, P. Coppi, Astrophys. J. 686, 1503 (2008).
7. R.A. Burenin, A.L. Amvrosov, M.V. Esselevich, Astron. Letters 42, 295 (2016). [Р. А. Буренин, А. Л. Амвросов, М. В. Еселевич, Р. А. Буренин, А. Л. Амвросов, М. В. Еселевич, В. М. Григорьев, В. А. Арефьев, В. С. Воробьев, и др., Письма в Астрономическом журнале, 42, 333, 2016]
8. F. Civano, M. Elvis, M. Brusa, A. Comastri, M. Salvato, G. Zamorani, et al., Astrophys. J. Suppl. Ser. 201, 30 (2012).
9. R. Cutri, M. Skrutskie, S. van Dyk, C. Beichman, J. Carpenter, T. Chester, et al., The IRSA 2MASS All-Sky Point Source Catalog, NASA/IPAC Infrared Science Archive. 06, http://adsabs.harvard.edu/abs/2003tmc.book.....C (2003).
10. E. W. Flesch, Publications of the Astronomical Society of Australia 32, 010 (2015); arXiv:1502.06303
11. A. Georgakakis, J. Aird, J. Buchner, M. Salvato, M. Menzel, W. Brandt et al., MNRAS. 453, 1946 (2015).
12. I. Gavignaud, A. Bongiorno, S. Paltani, G. Mathez, G. Zamorani, P. Moller et al., Astron. Astrophys. 457, 79 (2006).
13. M.A. DiPompeo, J. Bovy, A. Myers, D. Lang, MNRAS. 452, 312 (2015).
14. E. Kallountzou, F. Civano, M. Elvis, M. Trichas, P. Green, MNRAS. 445, 1430 (2014).
15. K. Hodapp, N. Kaiser, H. Aussel, W. Burgett, K. Chambers, M. Chun et al., Astron. Nachr. 325, 636 (2004).
16. S. F. Kamus, S. A. Denisenko, N. A. Lipin, V. I. Tergoev, P. G. Papushev, S. A. Druzhinin, Yu. S. Karavaev, Yu. M. Palachev, Journal of Optical Technology 69, 84 (2002). [Камус С. Ф., Тергоев В. И., Папушев П. Г., Дружицин С. А., Караваев Ю. С., Палачев Ю. М., Денисенко С. А., Липин Н. А., Оптический журнал 69, 674 (2002)]
17. G.A. Khorunzhev, R.A. Burenin, A.V. Mescheryakov, S.Yu. Sazonov, Astron. Letters 42, 277 (2016).[Г.А. Хорунжев и др., Письма в Астрономический журнал, 42, No. 5, 313, 2016]
18. A. Kolodzig, M. Gilfanov, R. Sunyaev, S. Sazonov, M. Brusa, Astron. Astrophys. 558, 89 (2013).
19. J. Liu, Astrophys. J. Suppl. Ser. 192, 10 (2011).
20. P. Madau, Astrophys. J. 441, 18 (1995).
21. P. Massey, K. Strobel, J. Barnes, E. Anderson, Astrophys. J. 328, 315 (1988).
22. I. McGreer, L. Jiang, X. Fan, G. Richards, M. Strauss, N. Ross, Astrophys. J. 768, 105 (2013).
23. A. Merloni, P. Predehl, W. Becker, H. Bohringer, T. Boller, H. Brunner et al., eROSITA Science Book , (2012). http://arxiv.org/pdf/1209.3114v2.pdf
24. S. Miyazaki, Y. Komiyama, H. Nakaya, Y. Kamata, Y. Doi, T. Hamana, Proceedings of the SPIE 8446, 02 (2012).
25. F. Ochsenbein, P. Bauer, J. Marcout, Astron. Astrophys. Suppl. Ser. 143, 23 (2000).
26. M. Overs, S. Randall, P. Nulsen, W. Couch, L. David, J. Kempner, Astrophys. J. 728, 27 (2011).
27. I. Paris, P. Petitjean, N. Ross, A. Myers, E. Aubourg, A. Streblyanska, et al., http://arxiv.org/pdf/1608.06483v1.pdf.
28. M. Pavlinsky, V. Akimov, V. Levin, I. Lapshov, A. Tkachenko, N. Semena et al., Proceedings of the SPIE 8147, 5 (2011).
29. G. Richards, A. Myers, C. Peters, C. Krawczyk, G. Chase, N. Ross et al., Astrophys. J. Suppl. Ser. 219, 39 (2015).
30. Y. Ueda, M. Akiyama, G. Hasinger, T. Miyaji, M. Watson, Astrophys. J. 786, 104 (2014).
31. C. Usher, D. Forbes, J. Brodie, C. Foster, L. Spitler, J. Arnold et al., MNRAS. 426, 1475 (2012).
32. D. Vanden Berk, G. Richards, A. Bauer, M. Strauss, D. Schneider, T. Heckman et al., Astron. J. 122, 549 (2001).
33. F. Vito, R. Gilli, C. Vignali, A. Comastri, M. Brusa, N. Cappelluti, K. Iwasawa, MNRAS. 445, 3557 (2014).
34. M. Watson, A. Shroder, D. Fyfe, C. Page, G. Lamer, S. Mateos et al., Astron. Astrophys. 493, 339 (2009).
35. G. Worseck, X. Prochaska, J. O’Meara, G. Becker, S. Ellison, S. Lopez, A. Meiksin et al., MNRAS. 445, 1745 (2014).

36. E. Wright, P. Eisenhardt, A. Mainzer, M. Ressler, R. Cutri, T. Jarrett, et al., Astron. J. 140, 1868 (2010).
Table 1. Redshifts for the quasi-random spectroscopic sample

| Name 3XMM | Date     | RA   | DEC   | OBJID SDSS       | 0−14 F     | i′PSF | zphot | spec  | QF     | zphotD15 | zphotR15 | L_{0.5−2} |
|-----------|----------|------|-------|------------------|------------|-------|-------|-------|--------|----------|----------|----------|
| J025459.8+192343 | 2015/10/13 | 43.7490 | 19.3957 | 1237673283585769514 | 1.448      | 19.17 | 2.60 | 2.81 | *1     | 44.98    |          |
| J062923.4+634935 | 2015/11/16 | 97.3468 | 63.8263 | 1237666462651646831 | 0.724      | 19.37 | 3.16 | 2.88 | 0      | 2.89     | 3.30     | 44.71    |
| J070407.4+310856 | 2016/03/04 | 115.1979 | 31.1490 | 1237654637323216268 | 0.687      | 19.36 | 2.88 | 3.04 | 1      | 2.98     | 2.92     | 44.74    |

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Table 1. Name — is the name in 3XMM-DR4 (3XMMJ...), Date — year/month/day when the first spectrum of the object was taken, RA is the right ascension, DEC is the declination, OBJID SDSS is the unique identifier in the photometric SDSS catalog, F_{0.5−2} is the 0.5–2 keV X-ray flux (erg/s/cm^2) normalized to 10^{-14}, i′ is the apparent magnitude in the SDSS i′ band (AB, PSF), z_{phot} is the photometric redshift in the K16 catalog, z_{spec} is the spectroscopic redshift, QF is the quality flag for z_{spec} (0 marks the redshift measured from several lines, 1 marks the redshift determined from only one Lyα line, *1 means that the object does not enter into the K16 catalog, *2 means that the object is a globular cluster in a nearby galaxy Liu (2011); Usher et al. (2012), *3 means that the object is a galaxy Owena et al. (2011), z_{photD15} is the photometric redshift (PEAKZ) in the catalog by DiPompeo et al. (2015), z_{photR15} is the photometric redshift (ZPHOTBEST) in the catalog by Richards et al. (2015), L_{0.5−2} — is the common logarithm of the 0.5–2 keV X-ray luminosity.
Fig. 3. Spectra of 19 quasar candidates (including 3XMM J025459.8+192343 that does not enter into the final version of the K16 catalog) taken with the ADAM spectrograph at the AZT-33IK telescope or (only 3XMM J125329.4+305539) with the SCORPIO spectrograph at the BTA telescope. For 3XMM J062923.4+305539 the horizontal line with marks indicates the set of absorption lines in the cloud of intergalactic gas at $z_{\text{spec}} \approx 0.17$: $\lambda_{H\beta} = 5696$ Å, $\lambda_{MgI} = 6077$ Å, $\lambda_{NaI} = 6895$ Å. The neighboring spectral channels were binned by two along the wavelength axis.
