Investigating Iron Kα Emissions Through X-ray Observations of NGC 2992

NGC 2992 is a Type II Seyfert galaxy whose galactic center AGN (Active Galactic Nucleus) has been observed in multiple studies as a test of a proposed "unified model" that characterizes the two Seyfert types to our viewing angle of an AGN and its surrounding torus. Through observations utilizing NuSTAR, a two focal plane module (FPMA and FPMB) detector that measures from ~4-70 keV (so, focusing on the hot corona of the AGN), and XMM-Newton, which measures ~0.5-10 keV (so, focusing on the cold material of the accretion disc), *The lively accretion disc in NGC 2992 - I. Transient iron K emission lines in the high-flux state*, published in 2020, suggests the presence of both narrow and broad Iron Kα lines at distances ranging from r_{in} = ~15-40 r_g to r_{in} > 50 r_g. **I propose a reanalysis of the campaign to validate the local origin of each emission Iron Kα line in the AGN.**

The Iron (Fe) Kα emissions present in NGC 2992 from the observations mentioned above (given net-exposure times for the time-averaged data as 92.6 and 92.8 ks for NuSTAR and XMM-Newton, respectively) show one constant, narrow line between 5.0-7.2 keV and three variable components: two (in 5.0-5.8 and 6.8-7.2 keV bands) from the "flaring region" of the AGN accretion disc, and one (in 6.5-5.8 keV bands) much further out locally but in the same structure. The Fe Kα emission line arises from interactions between X-ray photons and iron atoms in high-energy environments. This process begins with the Fe absorption edge, which occurs at 7.1 keV. Photons with energies exceeding this threshold have enough energy to eject an electron from the n=1 (K-shell) of iron, ionizing the atom and producing a sharp absorption feature in the X-ray spectrum. Following this ionization, free electrons can recombine with the ionized iron, leading to a cascade of energy level transitions. Eventually, the transition from n=2 to n=1 releases a 6.4 keV photon, producing the characteristic Fe Kα emission line. If the iron is moving at "slow" speeds (~100-1000 km/s), the emission line remains relatively "narrow", suggesting that it originates far from the central black hole. However, if the iron is located much closer to the black hole at "fast" speeds (~1.0×10^5 km/s), where gravitational and relativistic effects dominate, the Fe Kα line undergoes significant broadening and smearing due to Doppler shifting and gravitational redshift. In extreme cases, where the iron is moving at velocities approaching 100,000 km/s, the Fe Kα emission becomes highly relativistically broadened. This broad line can even blend with the 7.1 keV iron absorption edge, making spectral interpretation more complex. Additionally, if the Fe Kα emission originates very close to the black hole, it can exhibit variability on short timescales, sometimes fluctuating within just a few hours. Such rapid changes suggest that the emission is coming from the inner regions of the accretion disk, where intense gravitational forces and relativistic effects govern the motion of matter. The aforementioned paper lacks "hard X-ray" data, depending only on observations below the 10 keV threshold. Although observations in the > 10 keV region can complement the interpretation of the narrow part of the emissions, they are not required to analyze this "cold" band successfully. However, they are most relevant in observing more broad, "hot" emission components in regions closer to the AGN center due to their high emission energies. The proposed project, thus, will differentiate between the narrow and broad Fe Kα emission bands and validate their relative positions from the AGN center based on the procedures followed by the preceding paper.

Furthermore, prior data plots such as variability patterns (see Fig. 3 in the study) are smoothed in the observed bands from ~5.0-7.2 keV, which could decrease the SNR (signal-to-noise ratio) of the data and thus affect the conclusive location of the relevant emission bands. The proposed project would analyze how underestimations/overestimations described in the paper could affect the location of the Fe Kα emissions in the local AGN region by defining the proper "random" signal and its difference to "random" noise to improve the precision of the relevant, collective studies of NGC 2992. Additionally, the study utilizes a multitude of comparisons to proposed "models" and applies these models to the gathered data from NuSTAR and XMM-Newton observations to authenticate the precise location of the relevant emissions. Thus, given the underestimations/overestimations described in the paper, the project must also investigate if the given models by the paper are adequate to make the assumptions of the Fe Kα emissions provided, in conjunction with ruling out the possibility that such emissions could be the result of random fluctuations as initially proposed by Vaughan & Uttley in 2008.

To add, there is also a mention of a lack of "residuals" -the difference between an observed and a calculated position (the model)- in excess above 10 keV in the data, thus the lack of Compton reflection in that emission region. This claim must also be validated, but given the lack of hard X-ray data proposed by the paper, it is likely that other observations, whether future or preexisting ones, must be mentioned to verify the presence/nonexistence of Compton reflection in this emission region. Therefore, this proposed project could introduce possible conclusions made on the "soft X-ray" observations already conducted on NGC 2992, complementing a future study that includes both soft and hard X-ray data. This could demonstrate the importance of synchronized observations in both emission ranges by indicating if hard X-ray data is necessary, alongside a deep analysis of measured soft X-ray data, to rule out potential misinterpretations of the origin of Fe Kα emissions in the AGN. A mention of NICER (Neutron Star Interior Composition Explorer) data already taken on NGC 2992 could be resourceful in exploring this question, given its 0.2 - 12 keV range.