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X-Ray and microwave cosmology: synergy and competition. What do we expect from the next generation X-ray and microwave telescopes? (online talk)

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Our Universe is filled with cosmic microwave background radiation (CMB) which is isotropic and has the black body spectrum with temperature 2.7 Kelvin. No spectral deviations from a black body have been detected in the CMB monopole until now. However, the physics of the interaction of CMB photons with hot electrons predicted the presence of "shadows" in the angular distribution of CMB in the directions where clouds of very hot electrons Te~106-108 K exist in our Universe. Today we know that such objects exist and they are clusters of galaxies containing thousands of galaxies each, a lot of dark matter, and hot gas filling the huge potential well. The "shadows" with very peculiar frequency spectrum arise due to the Thomson scattering interaction of the CMB photons with the hot electrons. Today this method has permitted us to discover more than 8 thousand of clusters and even a protocluster of galaxies at relatively high redshifts 0 < z < 2. Behind many newly discovered rich clusters of galaxies, we see the extremely distant galaxies with their shapes distorted and brightness increased due to gravitational lensing by the huge gravitational potential of the invisible "dark matter" present in a cluster The amplitude of the CMB brightness shadow corresponds only to a few tens to hundreds of microKelvin.

There is another way to observe the same hot gas. On June 13th of 2019, Russia launched the SRG spacecraft with Russian ART-XC and German eRosita X-Ray telescopes aboard into the second Lagrangian Point of the Sun-Earth system. These telescopes are sensitive correspondingly to the hard and soft X-Ray photons. eRosita created the best map of the entire sky in X-Rays and was expected to discover more than 100,000 clusters of galaxies (i.e. all rich clusters of galaxies in the observable Universe) during the 4 years of surveying the full sky. At the same time, ground-based millimeter wavelength telescopes on the South Pole of the Earth and in the Atacama desert at 5 km altitude, equipped with tens of thousands of cryogenic bolometers in their focal planes, promise to detect the majority of these clusters due to their "shadows" in the CMB.

These two data sets will be very complimentary and there will be a lot of synergy. At the same time, there is competition: who will be the first to discover the most interesting (massive, high z, etc) clusters of galaxies? Ensemble of 105 clusters, their distribution in space, mass, and redshift will provide a unique sample of data for testing cosmological models.

The interaction of CMB photons with free electrons opens a unique way to measure the peculiar velocity of a cluster of galaxies relative to the unique system of coordinates in which the CMB is isotropic. Observers dream to measure peculiar velocities and even bulk and turbulent velocities inside the clusters of galaxies at any distance from us because both SZ effects (thermal and kinematic) do not depend on the redshift of the object.

I will try to present the results of a search for the clusters obtained by eRosita and ground-based SPT and ACT microwave telescopes. In addition, I will try to mention a few new observational effects which might be discovered in addition to new clusters of galaxies using the methods of CMB cosmology.

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