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DISTRIBUTION OF HOT INTERSTELLAR MEDIUM IN EARLY-TYPE GALAXY NGC4325

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ABSTRACT

Objective: To study morphology of the hot ISM in the environment of near by early type galaxy NGC4325 at redshift z=0.025714 using 30 ks X-ray data acquired from the archive of Chandra X-ray Observatory. The hot interstellar medium (ISM) in early-type galaxies plays a crucial role in understanding their formation and evolution.

Materials and Method:NGC 4325 has been observed by the Chandra Advanced CCD Imaging Spectrometer (ACIS-S) for 30 ks on 4 February 2003 (ObsID 3232) in very faint mode. We acquired level 1 event file corresponding to this observation from the Chandra archive and reprocessed it using the calibration files provided by the Chandra X-ray Center (CALDB V 4.6.7).

Results:. Tricolor map in soft ,mid and hard band revels that the contribution of soft and mid component is more in this galaxy while hard component is very less. The best fit wabs*apec model yielded into the minimum $\chi2 =$ 0.9240 for 300 dof and the best fit temperature equal to 2.9549 keV, metallicity equal to $0.0225Z_\odot$, where as the 0.5-7 keV X-ray luminosity equal to $1.8068*10^{+42}$ erg/s.

Conclusion: Systematic analysis of Chandra archive data on the X-ray bright NGC4325 revels that it consist substantial amount of hot ISM

Keywords: Galaxies: Individual(NGC4325), HOT ISM

INTRODUCTION

The hot ISM, also called coronal gas, refers to very hot nearly $T > 10^4$, low density gas nearly $n_H \sim 0.004 cm^{-3}$ which has been shock-heated by fast stellar winds and blast waves from novae and supernovae..

The existence of hot ISM in the galaxy was first postulated by American theoretical physicist Lyman Spitzer in 1956, in his paper *On a possible interstellar galactic corona*. In this article, Spitzer presents the four main arguments in favor of the existence of a galactic corona.[1]

In 1968, a rocket experiment by Bowyer et al. revealed the existence of diffuse x-ray emission in the energy range below 1 keV, which could be separated into an extragalactic and an "anomalous" component which appeared to be of Galactic origin.[2]

X-ray observations of early type galaxies have also detected a substantial amount of hot plasma heated to temperature about 10^7 K in a large fraction of ETGs .[3]

Observations by X-ray satellites have shown that the X-ray properties of bright elliptical galaxies can be explained by thermal emission of the hot interstellar medium (ISM). The estimated temperatures are $\sim$1 keV, and X-ray luminosities are typically $\sim 10^{40}$ ergs. Theoretical arguments indicate that the ISM is inhomogeneous; Mathews (1990) estimated that the $\sim 1 M_\odot$ of metal ejected by each supernova event into the ISM is trapped locally within the hot bubbles. Since in elliptical galaxies there is no overlapping of expanding supernova remnants after the galactic-wind period [4], it is expected that this inhomogeneity persists for a long time. The recent observation of *ROSAT* supports this idea by showing the existence of components with several temperatures in elliptical galaxies [5]. Global Parameters of the galaxy NGC4325 are as shown in table 1.

Throughout this analysis we adopt the cosmology with H0 = 70 km s−1.

MATERIALS AND METHODS

Table 1: Global parameters of NGC4325

Parameter	Value
Alternative Names	2MASS J12230666+1037166, GALEXASC J122306.60+103716.7, VCC 0616
Galaxy Morphology	E
RA	12h23m06.7s
DEC	+10d37m16s
Redshift	0.025714
Radial Velocity	7709
Dimensions	1.25'*0.80'
Magnitude and Filter	14.2g

NGC 4325 has been observed by the Chandra Advanced CCD Imaging Spectrometer (ACIS-S) for 30 ks on 4 February 2003 (ObsID 3232) in very faint mode. We acquired level 1 event file corresponding to this observation from the Chandra archive and reprocessed it using the calibration files provided by the Chandra X-ray Center (CALDB V 4.6.7). The X-ray peak of this cluster corresponds to (RA, DEC) 12 23 06.70 and +10 37 16.30, respectively. The raw 0.5-3 keV Chandra image of NGC 4325 is shown in figure 1. This image was then cleaned and the point sources present within the frame have been removed after their detection using the tool wavedetect. The source and the background regions for each of them were created using the tool roi and the holes formed due to the removal of the point sources were filled in using the tool dmfilth. Prior to this periods of high background flares were identifies and filtered out using the 3σ clipping of the full chip light curve employing task lc clean within CIAO.

RESULTS

X-ray emission

As X-ray emission from this galaxy appears of extended nature that fill the entire frame, therefore, we used the blank sky frames provided by CXC for applying the background correction.

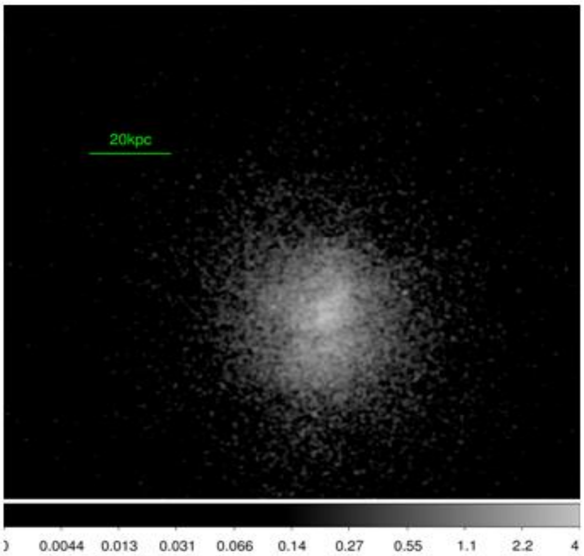

Fig. 1: 0.5-3 keV raw Chandra image of NGC4325. This figure reveals the extended nature of X-ray emission from this galaxy.

With a view to examine the energy distribution of X-ray photons in point sources image, we extracted X-ray photons in three different energy bands namely, soft (0.3 - 1.0 keV), medium (1.0 - 2.0 keV) and hard (2.0 – 7.0 keV) band. These three different energy band images were then used to derive the tri-color image of target galaxy NGC 4325. Adaptively smoothed tricolor images exhibiting the brightness distribution of the diffuse X-ray emission, after removal of point sources, in each of the target galaxy are shown in Figure 2(Right Panel). The color coding is such that, red color represents soft component (0.3 - 1.0 keV), green color represents the mid band (1.0-2.0 keV) and blue color represents the harder component (2.0 - 7.0 keV) of the X-ray emission. This image reveals that the ISM distribution is not isothermal, rather it exhibits structures in the spatial distribution of the X-ray emitting gas meaning that various regions emit at different energies. With an analogy to examine morphology of the X-ray emitting hot gas we have derived X-ray emission maps of NGC4325 employing 30 ks Chandra observations. A 0.3 - 3 keV background subtracted, exposure corrected, point source removed, 3 σ smoothed X-ray emission map for NGC4325 is shown in Figure 2(Left Panel). This image has been derived after subtracting ACIS reprojected blank sky from the science frame and then dividing it by the exposure map.

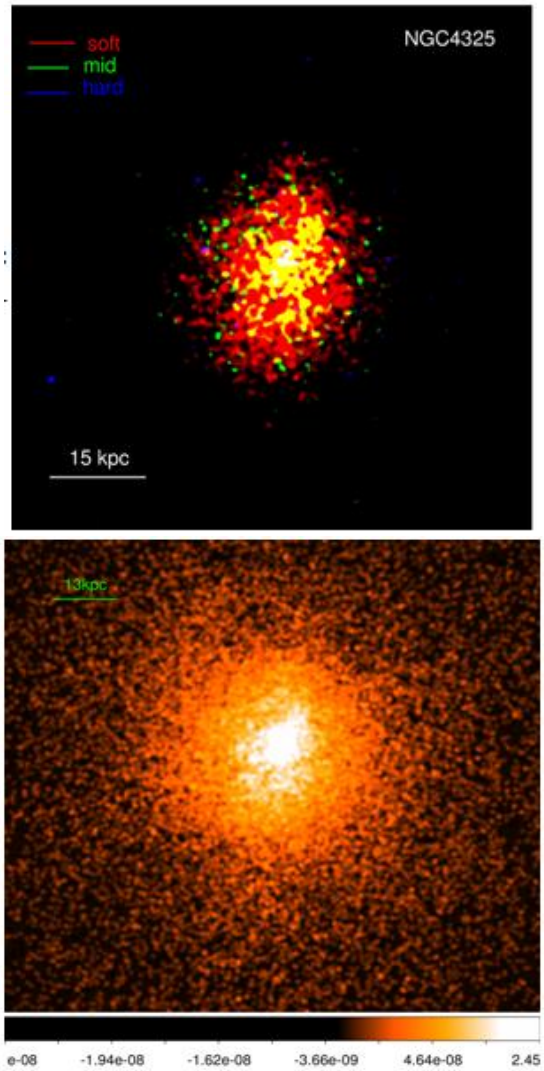

Fig. 2: diffuse X-ray emission map in the energy range (0.3-3.0)(Down).Tricolor map in different energy bands namely, the soft (0.3 – 1 keV, shown in red color), medium (1 - 2 keV, green color) and hard (2 - 7 keV, blue color)(Up).Surface Brightness Profiles

To investigate extent and morphology of the hot gas distribution within NGC 4325 we have computed its radial surface brightness profile. For this we have extracted 0.5-3 keV X-ray photons from a series of concentric circular annuli centered on the X-ray peak of the cluster. Width of each of the annulus was set equal 2′′ and this exercise was extended upto about 140″. Assuming that gas distribution in the cluster is in hydrostatic equilibrium with spherical symmetry, we fit the data points with one dimensional β-model given by

$$S(r) = S_0 \left[1 + \left(\frac{r}{r_c}\right)^2\right]^{-3\beta+0.5}$$

where, S(r) represents the surface brightness at the projected radial distance r, S0 represent the central brightness, β the slope parameter representing ratio of energy per unit mass contained in galaxies to the energy per unit mass content of the ISM, and rc the core radius. The azimuthally averaged surface brightness profile of the X-ray emission within this cluster is shown in Figure 3(Right Panel) . The best fit β-model yielded the slope parameter equal to β = 0.81 and the core radius equal to 31.10 pixels.

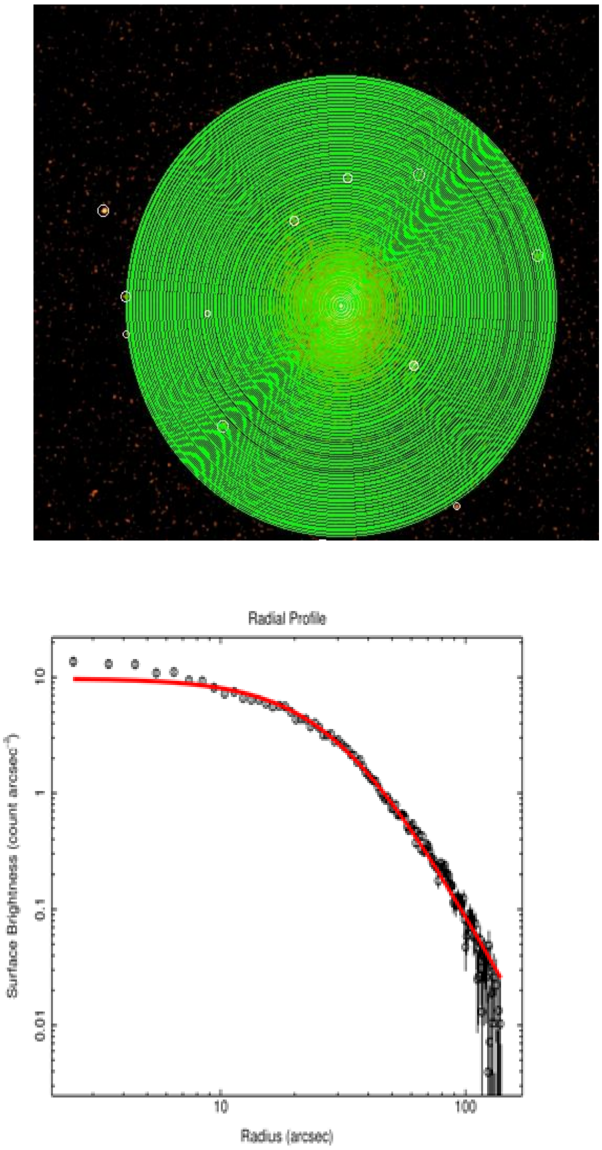

Fig. 3: Regions used for spectral extraction are overlaid(Up).Azimuthally averaged, clean background subtracted 0.3–3.0 keV surface brightness profile of NGC 4325. The best-fitting β model is shown as a solid line(Down)Spectal Analysis (Spectroscopy)

With an objective to examine the global properties of the X-ray emission from the ISM within NGC4325 we have extracted a 0.5-7 keV combined spectrum of the X-ray photons from within 140" circular region centered on the X-ray peak of the galaxy is as shown in Figure 4.. Assuming that the contribution from the nuclear source covers about central 2′′ region was excluded during the extraction. The source spectrum was then binned and was then imported to XSPEC for we fitted of with an absorbed single temperature apec keeping the Galactic extinction fixed and allowing the temperature and metallicity to vary. The best fit yielded into the minimum $\chi 2 = 0.9240$ for 300 dof and the best fit temperature equal to 2.9549 keV, metallicity equal to 0.0225Z⊙, where as the 0.5-7 keV X-ray luminosity equal to $1.8068*10^{+42}$ erg/s.

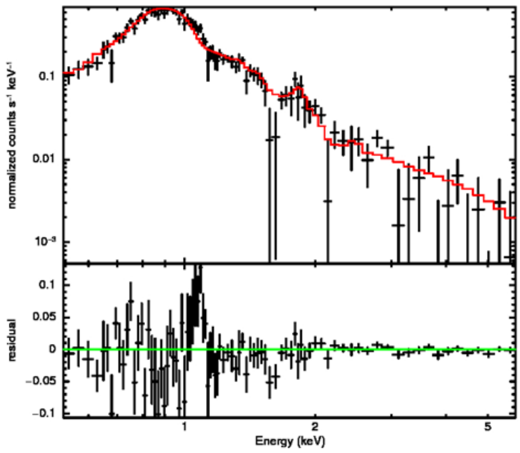

Fig. 4: Diffuse emission spectra of NGC4325 within 140".

CONCLUSION

Systematic analysis of Chandra archive data on the X-ray bright NGC4325 revels that it consist substantial amount of hot ISM. Tricolor map in soft ,mid and hard band revels that the contribution of soft and mid component is more in this galaxy while hard component is very less. The best fit wabs*apec model yielded into the minimum $\chi 2 = 0.9240$ for 300 dof and the best fit temperature equal to 2.9549 keV, metallicity equal to 0.0225Z⊙, where as the 0.5-7 keV X-ray luminosity equal to $1.8068*10^{+42}$ erg/s.

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