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FEATURES OF X-RAY RADIATION IN SYMBIOTIC STARS

Abstract. Modern observations of X-ray radiation from individual symbiotic stars are given to clarify their nature. Thus, the spectral features in a wide range of X-rays, optical and ultraviolet, and the rapid UV variability found in SU Lyn are consistent with the assumption that this is a symbiotic star with an accreting white dwarf. RT Cru is a prototype of symbiotics without burning shell on a dwarf with a hard type of x-ray radiation, providing an idea of the most internal structures of accretion. The X-ray type of radiation from the symbiotic star V1329 Cyg indicates that some of the high-energy radiation may occur as a result of strikes in the jet and beyond the symbiotic nebula. In the symbiotic recurrent new T CrB, a sharp increase in the rate at which the material reaches the innermost part of the accretion disk, that is, the boundary layer, is found, this can dramatically change its structure. X-ray satellite Suzaku investigated symbiotics in which X-rays exceed 10 keV (T CrB, CH Cyg, V648 Car). Suzaku CD-28 3719, Hen 3-1591, Hen 3-461, EG And and 4 Dra were observed, in which the models are compatible with X-rays emitted in the boundary layer between the accretion disk and the white dwarf. This paper discusses the various observable properties of individual symbiotic stars on space telescopes to identify common features that can explain the nature of symbiotic stars.
Keywords: symbiotic stars, the nature of X-ray radiation.

Introduction Spectral observations of symbiotic stars in optics have shown a complex spectrum, which is associated with duality. The hot compact component (usually a white dwarf, WD) contributes to the blue UV region of the spectrum, while the cold red giant dominates the spectrum on longer waves. Optical, infrared and ultraviolet spectral regions are rich in radiation lines from forbidden and allowed transitions, which arise mainly as a result of photoionization and recombination of a nebular plasma heated by a hot component. Radio, optical and X-ray observations show jets with velocities from several hundred to 1000 km / s and the thermal radiation from the red giant's ionized wind can even generate γ rays during eruptions. This paper discusses the various observable properties of individual symbiotic stars in the x-ray range, obtained by space telescopes, to identify common features that can explain the nature of X-ray radiation from symbiotic stars.

The results of modern observations on space telescopes

Observations from space telescopes XMM-Newton, Swift / XRT, Suzaku and others have made it possible to detect new sources of X-ray radiation in symbiotic stars. X-ray spectra with energies above 2 keV, obtained using Swift / XRT, are consistent with thermal radiation and are divided into three different groups. They allow us to understand the place of the formation of X-ray radiation: 1 group-associated with the boundary layer of the accretion disk. 2- consists of sources with a single, soft X-ray spectral component, which is associated with the region of collision of winds, 3- consists of sources with hard and soft X-ray spectral components, which exhibit UV-blink, which is a common property of symbiotic stars. The physical interpretation of the two spectral components of x-ray radiation and simultaneous ultraviolet photometry of Swift show that symbiotic stars with more intense x-rays tend to have more UV flicker, which is usually associated with disk accretion. [1]

Studies on symbiotic stars usually rely on low-resolution optical spectroscopy. Observations from Swift and ground-based optical spectroscopy made it possible to detect a hard x-ray source 4PBC J0642.9 + 5528, which was identified with the poorly studied red giant SU Lyn. The X-ray spectra, from optical to ultraviolet, and the fast UV variability of SU Lyn are in good agreement with the assumption that this is a symbiotic star containing an accreting white dwarf. The symbiotic nature of SU Lyn has so far remained unnoticed, since it did not detect strong emission lines in low-resolution spectra. Mukai et al. (2016) discovered that the red giant SU Lyn is the optical analog of a hard, thermal x-ray source and that it is a symbiotic containing an accreting white dwarf. [2] Its properties, including excess in UV, compared with non-interacting red giants and variability in the optical lines of the Balmer series, [NeIII] and Ca II, are consistent with the accretion onto a white dwarf without burning the shell. In general, observations confirmed that, in the X-ray range, optically thin plasma dominates in emission, which can be hot 2 × 108 K (kT 17 keV) and reach a maximum at 3 × 108 K with the assumption of cooling flux in the model. An analysis of the hard X-ray radiation properties of the SU Lyn allowed us to identify strong and variable internal X-ray absorption with rapid variability, suggesting that the absorber is located next to the accreting white dwarf. [3]

Luna G.J.M. et.al. [4] showed that the RT Cru object is a prototype of symbiotics without burning the shell on a dwarf; its hard type of X-ray radiation gives an idea of its most internal accretion structures. Over the past 20 years, RT Cru has experienced two similar events of increasing brightness, separated by an interval of 4000 days and with an amplitude of ΔV = 1.5 mag. Swift detected an increase in X-ray brightness, near the second optical peak. Spectral and temporal analysis of multiwave observations indicate that accretion continues through a disk that reaches the surface of a white dwarf. Moreover, the similarity of ultraviolet and x-ray fluxes indicate that the boundary layer of the accretion disk remained optically thin with respect to its own radiation during the increase in brightness when the accretion rate on WD increased to 6.7 × 10 -9 Mo / yr. [4]

Among symbiotics, there are also white dwarfs with quasi-stable burning of the shell on their surface, although the origin of this burning is not yet clear. Probably in slow symbiotic, it is associated with past thermonuclear release. So in June 2015, the symbiotic slow new AG Peg was seen only in its second optical flash since 1850. This recent outbreak had a much shorter duration and lower amplitude than the previous outburst, and it contained multiple peaks — similar outbreaks were seen in classic symbiotic stars such as Z And. Between June 2015 and January 2016, fast Peg X-ray and UV observations were obtained. The X-ray flux was noticeably altered in time scale, especially during the four days near the optical maximum, when the X-rays became bright and soft. This strong X-ray variability continued for another month, after which the X-rays became hard when the optical flux decreased. The UV flux was high throughout the flash, which is consistent with the quasistationary burning of the shell on a white dwarf. Considering that accretion disks around white dwarfs with shell burning usually do not produce noticeable X-rays (due to Compton-cooling of the boundary layer), X-rays are likely to have originated from blows in the emissions. Since the photoelectric absorption of x-rays has not changed significantly, the variability of x-rays can be directly attributed to the properties of the discarded material. This is how AG Peg transitioned from a slow symbiotic one (which supplanted the outbreak of 1850) to the classic symbiotic star. [5]

In another case, the X-rays of the symbiotic star V1329 Cyg detected with XMM-Newton showed a spectrum consisting of plasma with two temperature peaks: kT = 0.11 keV and kT = 0.93 keV. The impact velocities corresponding to the observed temperatures are about 300 km / s and about 900 km / s. No periodic or aperiodic X-ray variations were detected; the upper limits of the amplitudes of such changes were 46% and 16%, respectively (rms value). The nature of the soft component of the X-ray spectrum suggests that some of the high-energy radiation may occur as a result of impacts in the jet and outside the symbiotic nebula. Lower speed in HST observations corresponds to the speed of the expanding structure. Higher velocity may be associated with an internal impact at the base of the jet or with impacts in the area of accretion. [6]

According to the work of Luna G.J.M. et.al. [7] The symbiotic recurrent new T CrB showed a sharp increase in the rate at which the material reaches the innermost part of the accretion disk, i.e., the boundary layer, which can drastically change its structure. From data analysis from X-ray, ultraviolet and optical telescopes and the American Association of Variable Star Observers (AAVSO) in the V and B-bands, it was found that during the optical set, which began in early 2014 (Δ V≈ 1.5): 1 - hard X-rays, as seen from BAT, almost disappeared; 2- XRT X-ray flux decreased significantly, while the optical flux remained high; 3- The UV flux increased 40 times the dormancy value; and 4-x-ray spectrum has become much softer, and a bright, new, blackish component has appeared. Probably, the optical brightness event, similar to the one observed approximately 8 years before the most recent thermonuclear flash in 1946, is associated with disk instability. [7]

X-rays from five symbiotic stars observed from the Suzaku satellite were recorded. These objects were selected for deeper observations after their first detection using ROSAT and Swift. It turned out that X-ray spectra can be adequately adapted to the absorbed optically thin different thermal plasma models. Such models are compatible with X-rays in the innermost area of the accretion disk, that is, in the boundary layer. Based on the large amplitude of blinking (only detected in 4 Da), high plasma temperature and previous measurements of UV variability and brightness, it was assumed that all five sources are accretion-active due to the optically thick boundary layer. Considering the time interval between the previous and these observations, the long-term variability of X-ray was studied and it was found that its own X-ray flux and intermediate absorption column may vary depending on three or more factors. However, the location of the source of absorption and how changes in the rate of accretion and absorption are still elusive are still elusive. [8]

Currently, symbiotics are recognized as objects with X-rays. Of the 220 known systems, 45 were detected on X-ray waves, most of them with radiation in the range 0.3–10 keV. However, some of them were detected at energies up to 100 keV. X-ray satellite Suzaku investigated symbiotics in which X-rays exceed 10 keV (T CrB, CH Cyg, V648 Car). Suzaku CD-28 3719, Hen 3-1591, Hen 3-461, EG And and 4 Dra were observed with higher quality X-ray spectra. It was found that the X-ray spectra of all five sources can adequately correspond to the absorbed, optically thin thermal plasma models with a multi-temperature plasma. These models are compatible with X-rays that occur in the boundary layer between the accretion disk and the white dwarf. High plasma temperatures kT> 3 keV for all objects were higher than expected for headwinds. Based on these high temperatures, as well as on previous measurements of UV variability and UV brightness and on a large X-ray reflection amplitude, it was concluded that all five sources belong to objects with accretion, with mostly optically thick boundary layers. X-ray data allow us to observe only a small optically thin part of the radiation of these boundary layers. Considering the time between previous observations and observations, it was found that its own X-ray flux and intermediate absorbing medium can vary over three years or more. But the location of the absorber and the relationship between changes in the rate of accretion and absorption are still unknown. [9]

Conclusion

Thus, the region of formation of X-ray radiation at high plasma temperatures of about kT> 3 keV is most likely associated with the boundary layer between the accretion disk and the surface of the white dwarf, and a soft X-ray can form in the region of wind collision. X-ray spectra can be adequately adapted to the absorbed optically thin multi-temperature thermal plasma models. Such models can explain the formation of X-ray radiation in the innermost region of the accretion disk, that is, in the boundary layer. Sources with hard and soft X-ray spectral components, which are accompanied with UV blinking, are most likely associated with accretion into predominantly optically thick boundary layers.

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СИМБИОТИКАЛЫҚ ЖҰЛДЫЗДАРДЫҢ РЕНТГЕН СӘУЛЕЛЕНУІНДЕГІ ЕРЕКШЕЛІГІ

Аннотация. Жеке симбиотикалық жұлдыздардың табиғатын түсіндіруге, X-ray сәулеленуінің заманауи бақылау мәліметтері келтірілген. SULyn объектісінің спектрлік ерекшеліктері кең диапазонды рентгеннен, оптикалық және ультракүлгін және тез УК-айнымалылық табылды, бұл симбиотикалық жұлдыз ақ ергежей RTCru мен аккрецияланады, ергежейде қатаң рентгенсәулеленуі, қабықшаның жануы болмайды, бұл дегеніміз аккрецияның түпкі ішкі құрылымына жалпы тұжырымдама береді. Симбиотикалық жұлдыз V1329

Cyg X-ray сәулеленуінің кейбір бөлігі жоғары энергиялы сәулеленудің болу себебін симбиотикалық тұмандықтан тыс ағын соққыларының нәтижесінде болуы сүмкін. TCrB реккурентті жаңа симбиотикалық жұлдызда жылдамдықтың кенеттен өсуі, шекаралық қабат яғни аккрециялық дисктің түпкі ішкі бөлігіне материяның жетуі оның құрылымының өзгерісіне әкеледі. Suzaku рентген серігі сәулеленуі 10 кэВ асатын (TCrB, CHCyg, V648 Car) симбиотикалық жұлдыздарды зерттеді. Шекаралық қабатта аккрециалық диск және ақ ергежейдің рентген сәулеленуінде модельдері сәйкес келетін SuzakuCD-28 3719, Hen 3-1591, Hen 3-461, EGAnd және 4 Dra объектілеріне бақылаулар жүргізілді. Бұл жұмыста, симбиотикалық жұлдыздардың табиғатын түсіндіруге ғарыштық телескоптар көмегімен бағыланған жеке симбиотикалық жұлдыздардың жалпы ұқсас жеке қасиеттерін табу болып табылады.

Түйін сөздер: симбиотикалық жұлдыздар, табиғат X-ray сәулелену.

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ОСОБЕННОСТИ РЕНТГЕНОВСКОГО ИЗЛУЧЕНИЯ В СИМБИОТИЧЕСКИХ ЗВЕЗДАХ

Аннотация. Приведены современные данные наблюдений X-ray излучения отдельных симбиотических звезд для выяснения их природы. Так, спектральные особенности в широком диапазоне от рентгена, оптического и ультрафиолета и быстрая УФ-изменчивость, обнаруженная у SU Lyn, согласуются с предположением, что это симбиотическая звезда с аккрецирующим белым карликом. RT Cru является прототипом симбиотиков без горения оболочки на карлике с жестким типом рентгеновского излучения, обеспечивающим представление о самых внутренних структурах аккреции. Тип X-ray излучения симбиотической звезды V1329 Cyg показывает, что некоторая часть излучения высокой энергии может возникать в результате ударов в струе и за пределами симбиотической туманности. У симбиотической рекуррентная новой T CrB обнаружено резкое увеличение скорости, с которой материал достигает самой внутренней части аккреционного диска, т. е. пограничного слоя, это может резко изменить его структуру. Рентгеновский спутник Suzaku исследовал симбиотики, у которых рентгеновское излучение превышает 10 кэВ (T CrB, CH Cyg, V648 Car). Проведены наблюдения Suzaku CD-28 3719, Hen 3-1591, Hen 3-461, EG And и 4 Dra, у которых модели совместимы с рентгеновским излучением, возникающим *в пограничном слое между аккреционным диском и* белым карликом. В данной работе рассматриваются разнообразные наблюдаемые свойства отдельных симбиотических звезд на космических телескопах для выявления общих признаков, способных объяснить природу симбиотических звезд.

Ключевые слова: симбиотические звезды, природа X-ray излучения.

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