ENPLORING THE ENVIRONMENT

OF GYGNUS X-3

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Universidad de Jaén EVERY TIME THE BOGG CALLS US INTO HIS OFFICE, IT'S NOT TO GIVE US A RAISE ... AND THIS TIME WASN'T GOING TO BE ANY DIFFERENT ...

YOU KNOW WHAT HJELLMING ALWAYS SAID: CYGNUS X-3 IS A F*G PUZZLE!

THIS DAMNED SOURCE EMITS X-RAYS AND GAMMA RAYS, AND IT'S THE BRIGHTEST RADIO MICROQUASAR! IT MIGHT EVEN BE EMITTING AT VERY HIGH ENERGIES!

BUT THE DAMN THING CAN'T BE SEEN IN THE OPTICAL. IT'S TOO HEAVILY ABSORBED. SO WE DON'T KNOW WHAT ITS COUNTERPART IS, AND THERE'S NO WAY TO TELL HOW FAR AWAY IT IS!

AND IF WE WANT TO UNDERSTAND THE PHYSICAL PROPERTIES OF CYGNUS X-3, KNOWING ITS DISTANCE IS ABSOLUTELY CRUCIAL... IT'S MADDENING TO HAVE SUCH A POWERFUL, DAZZLING MICROQUASAR - AND STILL KNOW SO LITTLE ABOUT IT! THERE'S NOT MUCH CONSENSUS. FOR EXAMPLE, IN 2009, LING ET AL. PROPOSED A PREFERRED DISTANCE OF 7.2 KPC BASED ON X-RAY SCATTERING TAKING INTO ACCOUNT THE CYG OB2 ASSOCIATION.







COMPARING THE SIZE OF THE CYGNUS X-3 X-RAY HALO WITH THE TIME DELAY OF X-RAYS SCATTERED BY DUST, PREDEHL ET AL. (2000) OBTAINED A DISTANCE OF ABOUT 9 KPC. 9 kpc Predehl et al. (2000) 7.4 kpc McCollough et al. (2016) 7.2 kpc Ling et al. (200

THE MOST RECENT DISTANCE DETERMINATION IS THAT OF REID & MILLER-JONES (2023), BASED ON A PRECISE TRIGONOMETRICAL PARALLAX USING THE VERY LONG BASELINE ARRAY AT 43GHZ, WHICH PLACES CYGNUS X-3 AT 9-67 KPC.





SO FAR, THIS IS WHAT WE KNOW... AS YOU CAN SEE, THERE'S A BIG DIFFERENCE BETWEEN THE VARIOUS ESTIMATES! BUT WITHOUT SEEING THE COMPANION STAR, IT DOESN'T SEEM LIKE THERE'S ANYTHING ELSE WE CAN DO...

OR MAYBE THERE IS... THIS IS WHERE I WANT TO SEE YOU IN ACTION, YOU BUNCH OF SLACKERS. COME UP WITH SOMETHING SOON AND GET IN TOUCH WITH ME THE MOMENT YOU THINK OF ANYTHING. WE CAN'T JUST LEAVE IT LIKE THIS!

> AND WHILE WE'RE AT IT, LET'S TRY TO FIGURE OUT WHAT THE ENVIRONMENT AROUND THE MICROQUASAR IS LIKE. THAT'S ALWAYS GOING TO HELP US UNDERSTAND ITS ELUSIVE NATURE!

ALRIGHT THEN, GO WITH GOD. LET'S SEE IF YOU CAN EARN YOUR PAYCHECK, YOU RASCALS. CLOSE THE DOOR ON YOUR WAY OUT - AND DON'T TAKE TOO LONG TO SHOW SIGNS OF LIFE!









YOU'RE RIGHT, BUT WE MUSTN'T FORGET ABOUT THE JETS. CYGNUS X-3 ALSO EMITS JETS OF RELATIVISTIC PARTICLES. AND IN OUR OBJECT, THEY SHOULD BE NOTABLE, GIVEN THEIR POWER.

TRUE, JOSEP- SO, IT'S MOST LIKELY THAT THERE IS INTERACTION BETWEEN THE JETS AND THE SURROUNDING MEDIUM, BUT WE'VE ALREADY SEARCHED FOR IT IN THE PAST WITHOUT SUCCESS.

YEAH. INDEED WE DID. BUT MAYBE IT'S PRECISELY THE WIND FROM THE WOLF-RAYET STAR THAT COULD HAVE SWEPT THE MEDIUM AWAY, THUS PREVENTING US FROM SEEING IT... THINK ABOUT IT.

> DAMN IT JOSEP... NOW I'VE DRAWN THE SHORT STRAW. GOOD THING WE'RE GOING TO GET RICH... LET ME GO FOR A WALK AND SEE IF SOMETHING COMES TO MIND...

SO I WENT FOR A WALK... UNDER THAT CLOUDY SKY, I REMEMBERED THE KNOWN CASES WHERE A MICROQUASAR INTERACTS WITH ITS SURROUNDING MEDIUM...



FOR INSTANCE, AROUND GRS 1758-251, AS WE OURSELVES OBSERVED IN 2015 AND 2017.





BUT, AS I TOLP JOSEP, WE'VE LOOKEP AROUND CYGNUS X-3 AT RADIO WAVELENGTHS AND HAVEN'T FOUND ANYTHING CONCLUSIVE. COULP IT BE TRUE THAT THE SURROUNDING MEDIUM ISN'T PENSE ENOUGH FOR US TO PETECT THE INTERACTION?

COULP IT BE THAT THE WOLF-HOW THE HELL AM I RAYET WIND HAS SWEPT THE SUPPOSEP TO FIGURE MEDIUM AWAY AND THERE'S THAT OUT? NOT MUCH LEFT FOR THE JET TO COLLIPE WITH? TALK? ARE YOU BOSS? EVEN THINK I'VE GOT SOMETHING ... UNLESS ... UNLESS THE HI CLOUPS IN THE MEPIUM COULP GIVE US A CLUE!

JOSEP? CAN YOU

WITH THE

BETTER. I



















WELL... THE RADIUS OF THE GREEN CIRCLE IS OF ABOUT **7 ARCMIN.** AT THAT DISTANCE IT'S EQUIVALENT TO ABOUT 16 PC

> ONE MORE THING: THIS SAME CAVITY CAN BE SEEN IN A TRICHROMATIC WISE IMAGE (R: W4; G: W2; B: W1). I'M SENDING IT TO YOU...

OH, SH*T!!!

ALRIGHT, ALRIGHT. THIS SOUNDS GOOD, BUT TO BE CONVINCING, WE SHOULD HAVE A THEORETICAL MODEL THAT JUSTIFIES HOW CYGNUS X-3 COULD CARVE OUT THIS CAVITY IN THE MEDIUM. YOU KNOW WHAT I MEAN, RIGHT?



GOOP GRIEF. ONCE AGAIN, I'M THE ONE STUCK WITH THE HARP WORK. ANP ON THE USUAL SALARY, TOO.





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Para: Valenti Bosch-Ramon -		
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Asunto: HELP	10	
De: Peter C.Antropus – peter@ujaen.es	Firma: Ninguna	and the second s
Dear Valentí, I am facing an interesting problem, but I can't seem to find the right model. So I need help, and I thought of the best person for the job. Unfortunately, the best person was busy, so I have no choice but to turn to you. Could you give me a hand with this? I'll send you the details in another email. Fins aviat! Pedro		



A cavity produced by a continuous outflow interacting with a uniform cold medium will have a size $R \sim (L_{\rm W|j}/\rho)^{1/5} t_{\rm W|j}^{3/5} \quad \substack{\text{characteristic}\\ \lim_{w \in S_{\rm W}} f_{w \in S_{\rm$

If we use reasonable values for these parameters ($L_{w} \sim 10^{37} \text{ erg/s}$; Lj ~ 10^{38} erg/s ; $\rho \sim 1-10^{3} \text{ m}_{\text{H}} \text{ cm}^{-3}$; $t_{w|j} \sim 0.1-1 \text{ Myr}$) then we can obtain R ~ 16 pc, which at the 7.7 kpc we are assuming translates into the 7 arcmin angular distance of the cavity you observe...



Furthermore, it is likely that the medium around Cygnus X-3 is dense. For a typical characteristic time of 1 Myr, the density would be on the order of 10³ m_H cm⁻³, although if it were 0.5 Myr, the density would be an order of magnitude lower.

The jet can accelerate particles by interacting with the medium, but if the characteristic time of the jet's action would be much lower that that of the wind (more precisely $t_j \ll (L_w/L_j)t_w$) then the jet termination region within the cavity may have had too little time to become a significant emitter.

SO NOW WE'VE GOT EVERYTHING... LET'S SEE IF WE CAN START WRAPPING THIS UP. SO THE JETS WOULD BE YOUNGER THAN THE AGE OF THE SYSTEM... THE DISTANCE OF 77 KPC IS COMPATIBLE WITH A CAVITY CARVED OUT BY THE WIND/JET OF CYGNUS X-3 WHICH IS THEORETICALLY SOUND. BUT THE DENSITY MUST BE HIGH AND THE JET YOUNGER THAN THE SYSTEM.

WE HAVE EXPLORED THE MOLECULAR ENVIRONMENT AROUND CX3 AT THE DIFFERENT DISTANCES PROPOSED IN THE LITERATURE, NO TRACES OF INTERACTION HAS BEEN FOUND AROUND 10 KPC, ALTHOUGH IT COULD

THE DISTANCE OF OVER 10 KPC ALIGNS WITH HI DATA, SHOWING NO SIGNS OF INTERACTION DUE TO THE LOW-DENSITY ENVIRONMENT.

THIS APPEARS TO BE THE MOST PROBABLE DISTANCE. THE DENSITY WOULD BE LOW, AND SINCE CYGNUS X-3 IS SO FAR AWAY, ITS LUMINOSITY WOULD BE GREATER THAN WHAT IS COMMONLY ESTABLISHED. ITS RECENTLY SUGGESTED ULX NATURE WOULD BE MORE PROBABLE.



Gràcies Josep Maria per tots els bons moments de ciència i de vida per tot arreu del món

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