The Story of the Star that is A'Comin' and A'Goin'

(A Semi-Personal Coming and Going Science Story)

by Dr. Larry Krumenaker

In 1979 the eminent reporter for the Vatican newspaper, Father Guido Sarducci, reported on an astronomical discovery of note. This object was a star that part of the time was approaching the Sun in space, and part of the time it was going away from us. Most stars do one or the other, but not both. Because of Einstein's Relativity and that thing called time dilation, further investigation of the object in the Vatican Observatory archives revealed that inhabitants would age when moving away from us as it was moving at a high fraction of the speed of light, and then getting younger when approaching us. This would create problems for, say, couples who were just a few years of age apart, like 30 and 40 years old, for as they got younger, soon they would be couples of ages like 20 and (you can guess this) and in serious legal trouble.

Father Sarducci produced a photograph of the sky and pointed to the star-like object and mentioned its name; in his Italian accent it was named "Ess-uh Ess-uh Four-uh-Three-uh-Three." He called this The Star That is A'Comin' and A'Goin'.

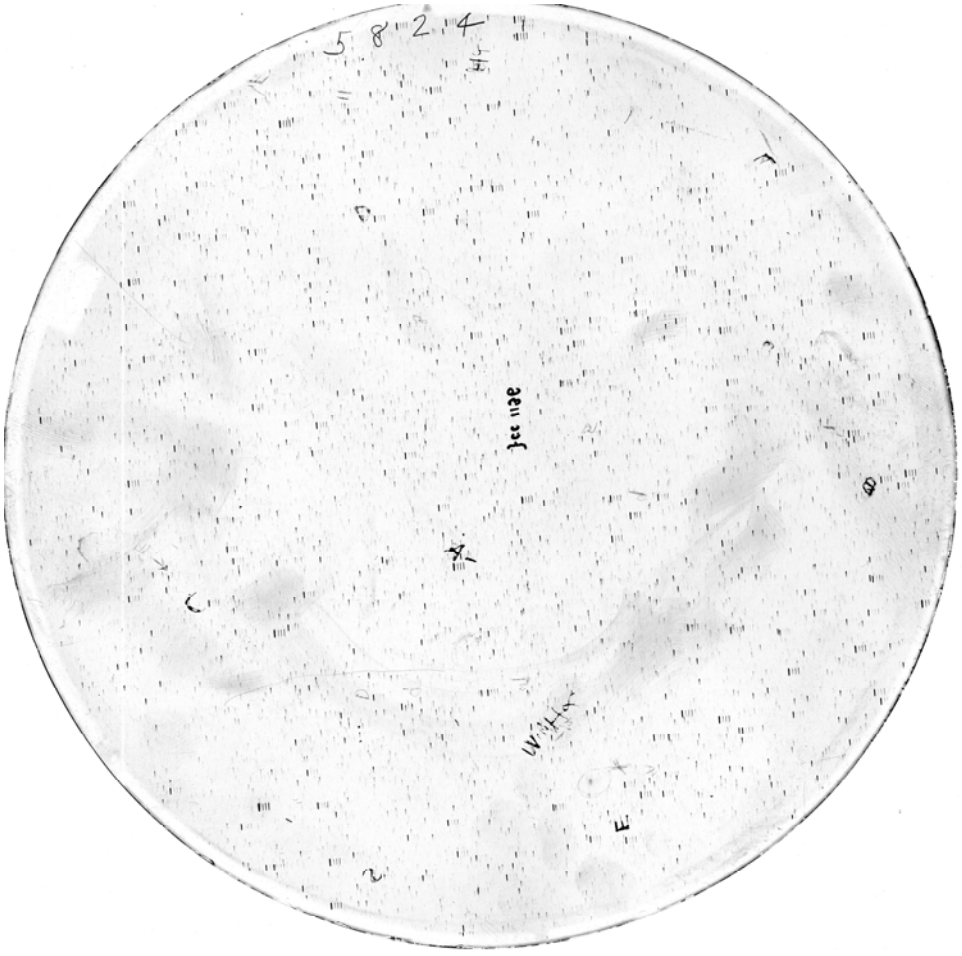
About the only things the Italian journalist (actually, comedian Don Novello, still doing this in his 80's) was the name and the fact that something WAS moving towards and away from the object at speeds a significant fraction of the velocity of light. The chart he held up can be compared to its discovery chart from a 1975 article in the *Publications of the Astronomical Society of the Pacific*.

No matter how you orient the discovery chart on the right of the graphic above, or resize it, nothing matches the photograph that Sarducci holds up.

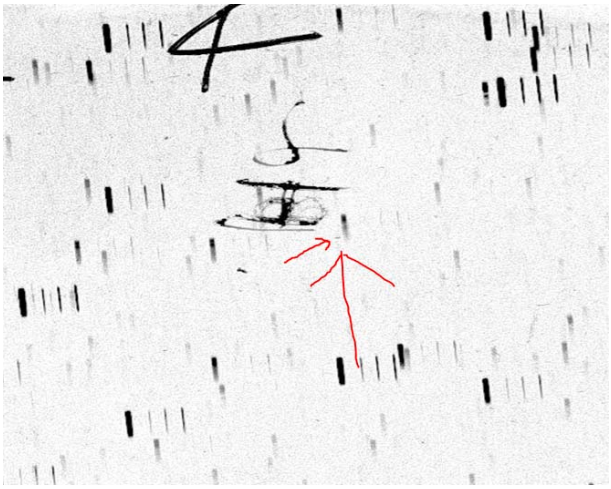
I should know. I made the discovery and the chart, back in 1973 and 1974, respectively.

Finding Microquasar #1

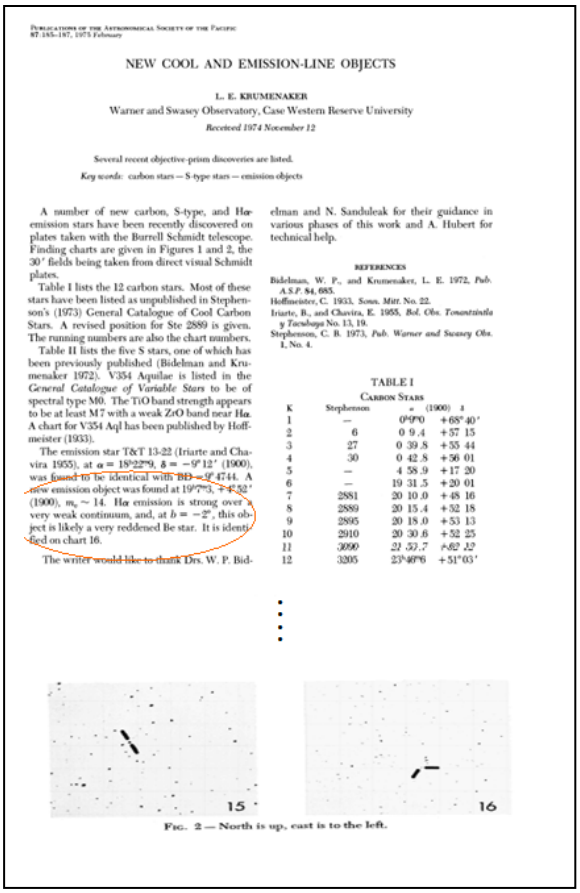
I was at the tail end of my astronomy-major undergraduate time at Case Western Reserve University, working for renown spectroscopist and my mentor Dr. William P. Bidelman. My work-study job was to scan Schmidt telescope wide-field photographic plates. This was LONG before digital recording, and film was not something professionals often used—plates were far better for long-term storage and more accurate usage and measurements. My plates were made with thin prisms placed in front of the telescope to make hundreds or thousands of tiny spectra on the plates, instead of dots of stars. As you can see in the following example, in most cases the spectra were just tiny streaks. I was looking for either lines of emission—extra light where the hydrogen-alpha line would be meaning there was glowing gas in the star's atmosphere or surroundings—or absorption lines slight offset from that location, meaning I had found a cool star containing carbon or silicon dioxide—carbon or S-stars they were called. I discovered quite a cache of them. Over the future years I managed to get more research done on some of them. One of the emission line stars turned out to be an irregular variable star, a T-Tauri-type star, only it had a periodicity; even six years it disappeared. I got a nice paper out of that.



But one emission-line spectrum was…odd. Can you see it? It is below the "4" in the plate number along the top edge. Had the plate been centered a little further 'down' I would have missed it. There is an H-alpha to the left of the spectrum in question. No? Here's a close-up….



See that thin emission line marked with the arrow? All other H-alpha emission-line stars (nominally called Be stars) have the rest of the spectrum visible in the background; this one is all but blank, just the emission line. Could be confused with a flaw in the photographic emulsion easily. Another odd thing…it was a bit wider than emission lines of other Be stars, though you can't see any on the closeup.



PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC
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NEW COOL AND EMISSION-LINE OBJECTS

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Several recent objective-prism discoveries are listed.

Key words: carbon stars — S-type stars — emission objects

A number of new carbon, S-type, and Hα-emission stars have been recently discovered on plates taken with the Burrell Schmidt telescope. Finding charts are given in Figures 1 and 2, the 30′ fields being taken from direct visual Schmidt plates.

Table I lists the 12 carbon stars. Most of these stars have been listed as unpublished in Stephenson's (1973) General Catalogue of Cool Carbon Stars. A revised position for Ste 2889 is given. The running numbers are also the chart numbers.

Table II lists the five S stars, one of which has been previously published (Bidelman and Krumenaker 1972). V354 Aquilae is listed in the *General Catalogue of Variable Stars* to be of spectral type M0. The TiO band strength appears to be at least M7 with a weak ZrO band near Hα. A chart for V354 Aql has been published by Hoffmeister (1933).

The emission star T&T 13-22 (Iriarte and Chavira 1955), at $\alpha = 18^h22^m9$, $\delta = -9°12'$ (1900), was found to be identical with BD −9° 4744. A new emission object was found at 19^h7^m3, $+4°53'$ (1900), $m_v \sim 14$. Hα emission is strong over a very weak continuum, and, at $b = -2°$, this object is likely a very reddened Be star. It is identified on chart 16.

The writer would like to thank Drs. W. P. Bidelman and N. Sanduleak for their guidance in various phases of this work and A. Hubert for technical help.

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Hoffmeister, C. 1933, *Sonn. Mitt.* No. 22.
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TABLE I
CARBON STARS

K	Stephenson	α (1900)	δ
1	—	0h9m0	+68° 40′
2	6	0 9 .4	+57 15
3	27	0 39 .8	+55 44
4	30	0 42 .8	+56 01
5	—	4 58 .9	+17 20
6	—	19 31 .5	+20 01
7	2881	20 10 .0	+48 16
8	2889	20 15 .4	+52 18
9	2895	20 18 .0	+53 13
10	2910	20 30 .6	+52 25
11	3090	21 53 .7	+62 32
12	3205	23h46m6	+51°03′

FIG. 2 — North is up, east is to the left.

A year later, during my M.S. time period at Case, I put together all my objects into an article, with charts, and published that 1975 article (with a transcription error in the coordinates, unfortunately, but the map was correct) and went to work on a planetary thesis. Back then the object was called by me K16. Shortly thereafter in 1977 Case astronomers C. Bruce Stephenson (my M.S. thesis advisor) and N. Sanduleak published their catalog of emission objects, listing K16 as their object 433, and their name stuck, SS 433. Not having a larger telescope nor in a Ph.D. program at the time, I left it for a future that wouldn't come in time for me. I would that out when astronomers would start to talk to me excitedly about my star during job applications, and I would be puzzled.

SS 433's future came in a hurry. In 1978 and 1979 it became the center of a flurry of research activity. British astronomers independently found the object with a more powerful telescope and couldn't identify the emission lines. Then Bruce Margon from UCLA looked at it and found the lines were pairs of lines that moved back and forth with a 160-day period. The movement of lines wasn't so unusual. The swapping of places for the lines was.

In 1979 astronomers in Oregon, Harvard and Arizona collectively found the generally 13th magnitude star was a variable (garnering it the name V1343 Aquilae) with a period also of 160 days and the lines being not double but triple, a stationary single line between the pairs, identifying one as Hydrogen-Alpha. Canadians at Dominion Astrophysical Observatory found the single line to move, too, indicating it was being gravitationally affected by a second object—SS 433 was a binary object—with a period of 13 days.

At this point, visual astronomers had reached their limits and astronomers in other parts of the spectrum began to examine the object. Radio astronomers found a signal at this coordinate, with half the period of the two-object revolution period, 6.6 days. How

odd! Others found it was a compact object—with bumps on either side, with measured velocities averaging 26% the speed of light. The flows varied over time, and flares occurred from whatever the more compact of the two bodies there was and both of them were apparently affecting a dim nearby supernova remnant called W50, indicating the two were either connected historically or at least co-located in space. That lead to an estimated distance of 15,000 light years (now revised to about 18,000). Gamma rays were detected, indicating that this was not a young object but an old one, therefore most likely the origin object for W50 after all.

So, What IS SS 433?

It is definitely a pair of objects, suspected to be some kind of post-supernova remnant such as massive black hole, a regular black hole or a neutron star with an accretion disk, plus a bloated star with a gaseous surrounding. The two orbit each other with a 13-day period, though that is changing over time, about 3 seconds per year. The compact object's gravity pulls that bloated star's gas to it as infalling material which then slams into it and gets rapidly ejected upwards, like hose water hitting a wall and has nowhere to go but up. These get ejected as those gas jets at 26% the speed of light.

But wait there's more.

The picture has gotten refined. The bloated star is now believed to be a late blue A-type star whereas the other object is a regular mass black hole. The latter's accretion disk, derived from its gravitational pull of the star's gaseous bloat is not aligned with the orbiting objects' plane but is tilted a bit. The jets ejected from the compact object are perpendicular to that accretion disk and thus tilted compared to the orbital plane. The jets and disk precess – wobble, like the Earth does over 25,000 years -- around an axis that is not quite perpendicular to the line of sight between SS 433 and Earth. Thus the high-speed jets sometimes have a component moving away from us, and sometimes moving towards us, and in real space the jets are not sci-fi shaped 'laser beams' but are corkscrew shaped! Furthermore, the dimmer of the objects partially eclipses the disk and bright of the two so that is what causes a 13-day variability; the gas infalling causes a 6.6-day variability because it sometimes is tilted away from the black hole companion, and the precessing jets cause the 160- (more accurately 162-) day variability found all those years ago.

This massive energy radiating pair was christened a microquasar. Why? Let's define that term and also 'quasar.'

A **microquasar** starts with a stellar black hole (or neutron star) with a mass several times that of a stellar companion. Matter pulled from the star forms into an accretion disk around the black hole. If this accretion disk becomes so hot from friction that it begins to emit X-rays and it also projects narrow streams or "jets" of subatomic particles at near-light speed, generating a strong radio wave emission, then you have a microquasar.

A **quasar** differs mostly by an enormous degree, by many orders of magnitude. A quasar begins with supermassive black hole with a mass ranging from millions to tens of billions of solar masses, surrounded by a gaseous accretion disc. Gas in the disk falling towards the black hole heats up because of friction and releases energy in the form of electromagnetic radiation. It may have a jet or may not. There is not single companion, of course, since there is so much other mass and infalling material. All these are at the least hundreds of millions of light years away, and further, back to the earliest years of the universe, but not created recently.

Are There Any More Microquasars?

Yes, though the definition of microquasar seems to have grown a bit more vague.

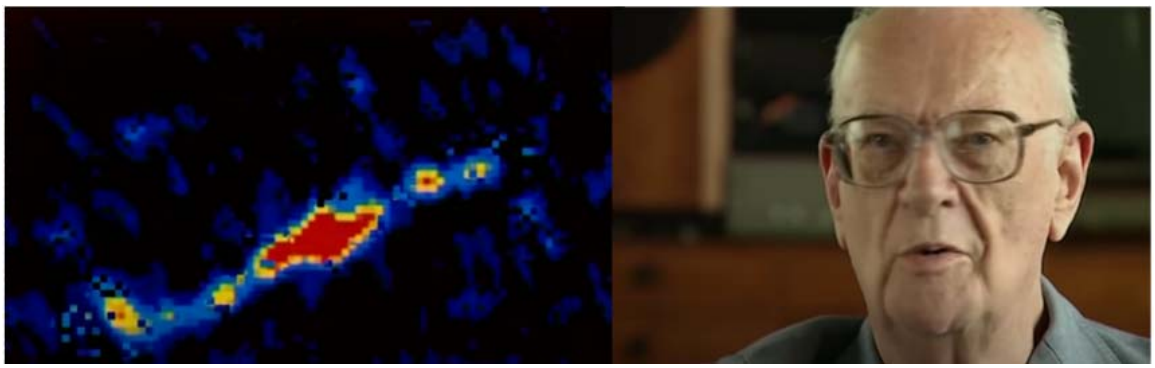
Wikipedia lists 18 of them, including some that go back to the earliest days of X-ray and radio astronomy, such as Cygnus X-1! The vagueness seems to be in that some of them have descriptions of the jets being *superluminal* jets at speeds at or near the speed of light, like at 90%, as opposed to *matter* jets moving at high speeds. Superluminal jets are a kind of optical illusion caused by the blobs of matter, projected on the sky at a sharp angle, appearing to move faster than they actually do. Not all seem to have their 'matter speeds' measured. At least one of the 18 is in another galaxy, and all but one is fainter—often MUCH fainter--than SS 433. Most are recently detected and poorly studied, other than the ones like Cyg X-1 that have been known for decades. All vary in brightness and/or X-rays or gamma rays, and all have had a stellar companion discovered --sometimes recently!

SS 433 (née K16) was discovered 50 years ago. Of all the microquasars it is probably the best studied AS a microquasar and the only one that has made it even a little bit into popular culture. It has set the standard and is clearly the prototype. And it was the first.

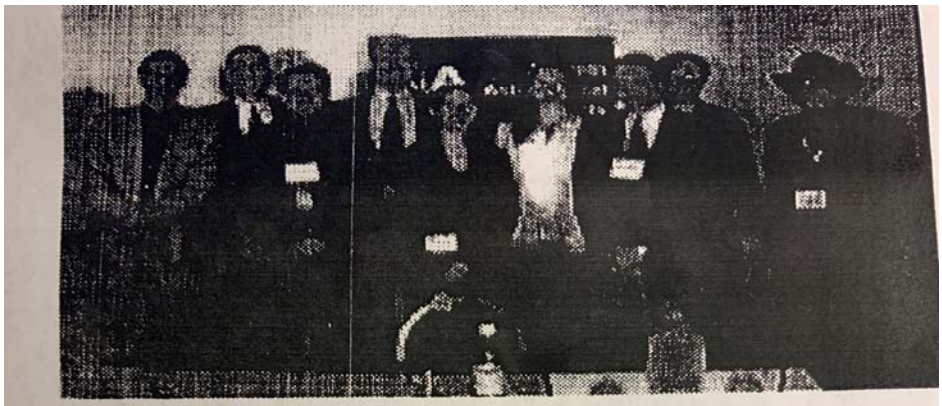
Personal Epilogues

In 1997 Sir Arthur C. Clarke, the famous British science and science fiction writer, in a BBC television program, named SS 433 "one of the seven wonders of the world." It was the only object on his list that was in outer space. While he was jovial in his reporting, he was not quite as humorous but far more accurate in his reporting than Father Sarducci.

As a science journalist and, later, an officer of the International Science Writers Association, I got to know him and to thank him profusely for the honor.



Then, at the 2003 American Astronomical Conference in Atlanta, Georgia, on the 30th anniversary of its discovery, a briefing on SS 433 took place with as many observers of the object as could be gathered. During the briefing yours truly was credited as its discoverer. In this rather poor photocopy from the then-print edition of the post-conference newsletter, this photograph shows the participants, with myself at the extreme right in the hat.



A briefing on SS433 brought together current and past researchers. They included NRAO radio observers Gregory Taylor, Amy Mioduszewski, and Michael Rupen (first, sixth, and eighth from the left), Georgia State U. optical investigators Douglas Gies and Todd Hillwig (second and third from left), MIT X-ray astronomers Herman Marsha and Laura Lopez (fourth and fifth from left), Bruc Margon (STScI, third from the right) who helped discover SS433's huge periodic Doppler shifts, an Georgia journalist Lawrence Krumenaker (far right), who as an astronomy graduate student firs reported emission lines in the star.

Near the time of SS 433's 40th anniversary (actually, in 2012), I had a surprise phone call from someone claiming to be from the London Museum of Science. He wanted to know if I was the fellow who had found the object known as SS 433. After ascertaining that this really wasn't a practical joke, I was able to send them my digital copies of the discovery plate (seen earlier in this article) and some other materials and, lo and behold, they created an exhibit on SS 433, citizen science, and the study of the object, with myself, two other scientists that I didn't know currently studying it, and one Stephen Hawking as four key persons involved in the science. Deciding that most of the time one usually doesn't get an exhibit on yourself unless you are dead and I didn't want to wait that long, I actually went to London to see the exhibit. It was the second time Hawking and I were near-misses with each other. But I got first billing.

SS 433 has become like my child, and Papa is proud of how his offspring has grown up!

Personal Note, on A'Comin' and A'Goin', InDepth

Fifty years ago SS 433 was my debut into becoming a professional in astronomy. It was my point of *a'comin'*. Even when I went from pure research into astronomy

education and planetariums, and then in astronomy and science journalism, astronomy was always there, SS 433 was a point of some notoriety and pride, and even occasionally I got to do some more research.

Now it is fifty years later. It is clear that some parts of this have gotten to their time to be *a'goin'*.

Among other things, you may have noticed that this issue is totally public, not for Paid Subscribers only, and there is no Buy a Subscription button. One of those *a'goin'* things is this newsletter. With this issue, it will be terminated, or possibly absorbed into being a special issue for paid *The Galactic Times* subscribers. I have not decided that, exactly. But it clearly isn't *a'comin'* neither anywhere near expectations nor as viable or sustainable economically as hoped so it will be *a'goin'* away. Those who paid subscriptions, I thank you deeply; you will get a prorated refund from Substack shortly.

I also have some unplanned major surgery coming up. This also is a good reason to make my other various newsletters *a'go* away, or in some cases perhaps, *a'go on hiatus*. On the other hand, books, some almost done and long postponed because of writing three newsletters essentially full-time, and others to start, especially with the huge mass of newsletter (and evergreen *Classroom Astronomer Magazine*) material to mine—writing 12,000 or more words per month for two years does accrue a LOT of material!--may be worth working on during my several months of convalescence. I'll send a follow-up posting with a survey on those soon. I hope you will respond.

Thank you for reading.

Signing off and a'goin',

Dr. Larry Krumenaker

Dr. Larry Krumenaker is an astronomer, educator and long-time science journalist who has lived and worked in 9 states plus Korea and Germany, most recently at the Heidelberg Institute for Theoretical Studies and the University of Cologne, before ending up in Alabama. He is the author of six books in astronomy, computing and historical tourism with two more books imminent. Dr. Krumenaker is also the publisher and primary writer of *The Galactic Times* and *The Classroom Astronomer* newsletters.