Hamilton Amateur Astronomers

Event Horizon

June 1998 Volume 5 Issue 8

Black Holes- Your Questions Answered

-Denise Kaisler
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Yesterday, my colleague Jamie walked into my office and said. "This is really far out, but do you know anything about wormholes?"

"Wormholes?" I scratched my head. "You mean black holes?"

This was the beginning of a long conversation, during which Jamie learned about black holes and I learned two things. The first thing is that all kinds of people are curious about these exotic objects. The second thing is that people often have to resort to scientifically inaccurate media like Star Trek to satisfy their curiosity.

With that in mind, I sat down last night and started typing away madly. The result is this series of answers to Jamie's questions and, hopefully, to some of yours as well.

What in tarnation is a black hole, anyway ?

A black hole is basically a singularity (a point of infinite density) surrounded by an event horizon - a sphere which marks the point of no return. If anything goes beyond the event horizon, it can't escape from the black hole's powerful gravity. Escape velocity is the speed of light and Einstein tells us that nothing can go faster than light, or even cruise at light speed. That's why black holes are black. Not even light can escape from them.

Since the event horizon is a sphere, it has a definite size. In 1916, a guy named Schwarzschild discovered that the radius of the event horizon depends only the mass of the singularity. So, he did what scientists love to and slapped his name on his discovery. That's why the event horizon is also known as the **Schwarzschild radius**.

If aliens invaded our solar system and somehow turned the sun into a black hole, its Schwarzschild radius would be a mere 3 km! The Earth and the other planets would continue orbiting as before. They wouldn't get sucked in.

Where do black holes come from?

A black hole forms when a sufficiently massive object collapses in on itself. We understand this process fairly well for stars with masses about 20 times that of the sun. But new evidence shows that there might be black holes at the centers of galaxies too. These giant singularities could contain thousands of solar masses.

If we can't see black holes, how do we know they exist?

Well, first of all Einstein's Theory of General Relativity predicts singularities. But for a long time, even Einstein himself was reluctant to admit that a naked singularity could exist in the real universe. But then people realized that if a singularity did exist, it wouldn't jut be sitting there on its own, it would be surrounded by an event horizon, which would keep the singularity from messing up surrounding space-time too much.

Observational evidence for black holes is also mounting. In the 1970s, astronomers looking for X-rays from space discovered a strong point source in the constellation of Cygnus, the Swan. These X-rays are thought to come from a disk of stellar material that is orbiting a black hole. The gas is heated by friction while it orbits and the atoms of the gas get excited. But atoms don't want to be excited, they want to be stable. So, they get rid of their excess energy by giving off X-rays.

The discovery of these X-ray sources and the resulting interest in them prompted John Archibald Wheeler (a scientist who has no other claim to fame, as far as I know) to come up with the name **"black hole"**.

One thing that has lots of astronomers hopping is the search for gravity waves. Black holes are usually stationary. But if a black hole is disturbed - say by a collision with another black hole or by swallowing a star - Einstein's math says that it will send ripples into the space-time continuum. Right now, one of the sexiest projects in astronomy is building a gravity wave detector so we can look for black holes. Also, most people think gravity waves don't change when they encounter matter, so this means that gravity waves may hold important information about the beginning of the uni-

(Continued on page 6)

inside...

Editor's Report

As many of you already know, I am moving to Toronto this September. For a number of reasons (primarily time constraints) I will not be able to continue to edit the Event Horizon and I'd like to take this opportunity to encourage anyone interested in being more involved in the club to take over. The requirements are access to a PC which can run Microsoft Publisher and a few hours a month of your time. E-mail obviously helps since it makes it a lot easier for people to get their articles to you.

It may seem like a big job but MS Publisher is very user friendly and the rest of the club is extremely helpful. As you know, we've had almost every issue jam-packed with articles. Most of the time I was simply cutting and pasting and playing with clip-art! It's also a great way to get to know your fellow members. If you're interested and want some more information regarding what the position entails please call or e-mail me at

527-8405
webb@physics.mcmaster.ca

If I receive any articles over the summer we will have a summer issue - otherwise, see ya in the fall!

On another topic our Korean Correspondent Denise Kaisler will now reporting from L.A.!

Chair's Report

Believe it or not there are only two more general meetings left for the current council. That means it's not too early to start thinking about joining the council. It is always nice to see some new faces with new ideas. There aren't any special requirements to be on the council other than a willingness to devote some of your time to keep the club going. None of the positions are especially onerous. If you have some ideas about what the club should be doing this is the best opportunity to see them implemented. There are positions on the council that don't have specific duties if you just want to see what it's all about. You have the whole summer to think about it.

Speaking of the summer, the next few months are prime time for observing. Star "parties", warmer nights, fewer clouds and the Milky Way is well placed. I probably shouldn't mention the bugs and shorter nights. You can't really appreciate the night sky until you get to a dark site such as at Silent Lake or near Mount Forest where Starfest is held. I've said this many times before but I think that it's worth repeating - You don't need a telescope to attend a star party. There are lots of telescope owners who are willing to show you the night sky. Even unaided observing is a pleasure when the sky is really dark.

There are many different kinds of observers, finding as many objects as possible in a night, the challenge of finding something really obscure and difficult, just seeing something new or visiting and savouring old favourites. Then there are the people who don't mind seeing photons second hand; photographers and CCD owners. (You might detect a slight bias there.) What kind of observer are you? No matter which category you fit into get out and do it!

- Stewart Attlesey

HAMILTON AMATEUR ASTRONOMERS

Event Horizon is a publication of the Hamilton Amateur Astronomers (HAA).

The HAA is an amateur astronomy club dedicated to the promotion and enjoyment of astronomy for people of all ages and experience levels

The cost of the subscription is included in the $15 individual or $20 family membership fee for the year. Event Horizon is published a minimum of 10 times a year.

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Something Old, Something New

-Everett Cairns

While testing the figure on a six inch mirror that I was attempting to figure, I stumbled upon a simple test procedure that gives an easily interpreted visual plot of ray ***transverse*** aberration at the focus as a function of the radius on the mirror from which the ray was reflected. To explain how this happened I should first emphasize some less appreciated features of the Foucault test, the most common mirror test in use by amateur telescope makers.

In 1858 Leon Foucault introduced this simple test which allows one to see and measure the surface profile of a mirror to a small fraction (~1/100) of a wavelength of light. For all its sensitivity, the test requires little more than an illuminated pin-hole and a knife edge.

Imagine a perfectly spherical mirror illuminated by the pinhole source near its centre of curvature. Nearby would be the reflected image of the pinhole. Now if you were to move a knife edge from *right* to *left* into the image while viewing the mirror from just behind (i.e. away from the mirror) the mirror would in principle darken everywhere simultaneously as you covered the image point. However if one area on the mirror had the wrong slope, then rays from this area would either be intercepted early and darken early as the knife advanced, or be intercepted late and hence not darken as the rest of the mirror darkened. Looking at the mirror you would see shadows moving *left* to *right* or *right* to *left* as you advanced the knife, indicating the mirror deviation from spherical.

What you have is a long optical lever where a small tilt angle of say one wavelength (5/100000 cm) over say 3 centimeters of mirror surface at some position on the mirror (say 4 cm) distant from the axis is measured (after doubling by the laws of reflection) as a *transverse* ray aberration at the knife edge at the image distance (say 250 cm). The transverse ray aberration is then 2x250/3 as large as the surface error, or 8/100 mm, which is easily measured. In fact most Foucault tests measure how far down (or up) the mirror axis you must go until the aberrant ray crosses. Because of the shallow angle between the ray and the mirror axis this distance is for our example 250/4 times larger again, or 5 mm. Measuring 5 mm *longitudinal* aberration is a piece of cake.

More often one is testing a surface of revolution such as a paraboloid, rather than a sphere. To make this test quantitative it is then usual to place a mask over the mirror leaving only several paired areas at equal distances left and right of centre uncovered. Then, by measuring the position along the mirror axis where a pair of openings darken simultaneously it is possible to determine the ray crossover for this zone. Almost any telescope making nut can tell you that the longitudinal aberration from the paraxial focus for a zone at radius "r" on a parabaloid of focal length "R"/2 is given by r^2/R. Comparing measured with predicted longitudinal aberrations it is possible to determine the mirror shape as you attempt to polish it to a true parabaloid within 1/8 of a wavelength or better.

What is often forgotten about the Foucault test as just described is that the crossover point is not the true focus for either opening in the masked pair. In fact if the long. aberration is r^2/R then it follows from the ray slope that trans. aberration is r^3/R^2 at the paraxial focus.Then at a distance y further from the mirror the ray is a lesser distance x from the axis given by $r^3/R^2-yr/R$. A quick application of the calculus requiring that $dx/dr=0$ locates the focus at $y=3\ r^2/R$, a full 3 times further from the paraxial focus than the crossover! The rays from the two openings in the test mask pair cross the axis before coming to focus at two distinct points on opposite sides of the axis.

The considerations of the preceding paragraph lead Ricardo Platzeck and E. Gaviola of Cordoba Observatory in Argentina to elaborate in 1939 what came to be known as the Gaviola test. Their argument was that it would be much easier to locate the two foci accurately and measure their separation 2x as a function of distance y down the axis from the paraxial focus. Not being gluttons for punishment, they, as had others, substituted a slit for the pin hole to get greater illumination. Instead of the knife edge they proposed a fine wire to block the light at the two images of the slit formed by the left and right openings in the mask. They felt that the wire eliminated some systematic errors. Of course the option was always there either to measure the small distance 2x at a given y or to measure the longitudinal aberration for a given r. The latter would be 3 times that of the Foucault test.

So it began, armed with a 10 micron slit, a 10 micron strand of lint for a wire, and a $50 diode laser (something new) to illuminate my slit I began my first wire test. Slowly I advanced the wire from left to right and slowly the shadows on the mirror advanced from *top* to *bottom*!

to be continued:

Important safety note: Should you try this and you don't want your eyeball abused, view the light after the wire as projected on a fine ground glass and ***never*** directly!

The Junior Naturalists

-Bob Botts

Besides being a member of HAA, Miranda is a member of the Hamilton Junior Naturalists. This group of young nature enthusiasts, were the audience for Tracy Webb's slide lecture on *The Solar System* earlier this year, at the Interpretive Centre of the RBG, at Cootes Paradise. Unfortunately, the weather wasn't co-operative at that time, so a tentative sky encounter had to be cancelled.

The season finale was to be a lecture on bats, followed by a 'bat hike' and a campfire, complete with toasted marshmallows and bananas. The lecture on bats was informative and I had the opportunity to have a brief discussion on the nocturnal habits of bats, with the guest lecturer.

Unlike the rest of the general population, bats are no strangers to astronomers, as bats are feeding most actively at dusk ... the time when most of us are outside setting up our equipment. Bats are voracious hunters, and the species native to Ontario are known to capture their insect prey at a rate of 10/min., which makes them beneficial to have about, when the mosquitoes are at their worst. Those of you who enjoy lunar observing, may have also noticed that bats aren't as active when the Moon is full.

Our bat hike culminated with the release of a live bat captured in the halls of the U of T.

Since it was a warm night, and the parents had planned to be out a little later, I took the opportunity to set up my scope in the parking lot, and follow-up on Tracy's presentation.

The sky was a pitiful mag 3, so aside from the waxing crescent moon, I wasn't hopeful that much beside the brightest globulars were potential targets. It's too bad that the planets aren't current evening objects. Incidentally, even LX200 technology suffers from hazards of 'tripod bump', and with bright stars having more than 20 degree separation, many not-so-subtle 'scope nudges', meant that one needed to realign with some frequency.

As always, the moon is an incredible crowd pleaser. Even though atmospheric turbulence caused excessive shimmering of the image, first time observers, were left awestruck. Those naked-eye, observers waiting for their chance at the eyepiece, noticed 'Earthshine' for the first time. Later in the evening, as the gathering was ending, and the lineup to the scope subsided, it became possible to target the brighter globulars, M13 and M92 in Hercules, the ring nebula, M57 in Lyra and even the Whirlpool galaxy, M51, 'not' in Ursa Major. Vega was chosen as an example of a bright star, and I became 'aware' of how many people associated Vega with the movie *Contact.* It appears Carl Sagan has been able to touch the minds of many, even after his passing.

Upon reflection on the evening, I found myself wondering what 'spiels' other members use when guest-hosting groups around a telescope. I'll take the opportunity to share a new-favorite, offered by Bruce McCurdy of Edmonton...

"I also have a little fun showing Cor Caroli. My spiel goes something like this: The star's full name is Cor Caroli Regis Martyris, literally 'the Heart of Charles, the Martyr King'. It was likely named by some royalist sycophant in the 17th century. It's actually a double star ... the way I see it, the bright star is Charles' heart, and the dim bulb to the lower left is his head in the basket!"

They are ill discoverers that think there is no land, when they can see nothing but sea ... Francis Bacon

Answers to Last Month's Astro-Quiz

- Denise Kaisler
kaisler@soback.

the bird of paradise - *Apus*
the seal - *fictional*
the altar - *Ara*
the herdsman - *Bootes*
the chisel - *fictional*
the southern fish - *Piscis Austrinus*
the ship's sail - *Vela*
the frog - *fictional*
the the ship's compass -*Pyxis*
the river - *fictional*
the mountain - *Mensa*
the giraffe - *Camelopardis*
the butterfly - *fictional*
the eastern cross - *fictional*
the chariot - *fictional*

Constellation of the Month: Draco

-Margaret Walton

With vast convolutions Draco holds
Th' ecliptic axis in his scaly folds.
O'er half the skies his neck enormous rears,
And with immense meanders parts the Bears.

-Erasmus Darwin's Economy of Vegetation

Draco, The Dragon, never sets in the Northern Hemisphere. Some 4000 years ago it was the guardian of the star that never moves - the north celestial pole. Due to precession, the honour of being the pole star has passed on to another, but Draco remains. As the year goes on, Draco turns upside down. Its midnight culmination is June 22.

Zeus was given three golden apples by his wife, Hera. He placed them in the Garden of Hesperides, owned by Atlas. The dragon Ladon guarded the apples. Hercules' 11th labour was to steal the golden apples. Atlas was the only one who could approach Ladon. Hercules tricked Atlas into stealing the apples for him. As a punishment for failing to guard the apples, Ladon was placed in his circumpolar position to forever guard the heavens.

STARS

Thuban - Thuban's claim to fame was its prominence as the Pole Star around 2800 BC. Due to precession, Polaris is now the Pole Star. Thuban has a magnitude of 3.7 and is blue/white in colour.

OBJECTS TO SEE IN DRACO

NGC 6543 - The Cat's Eye Nebula. This is a beautiful nebula, showing a blue/turquoise color. It is estimated to be 1000 years old, and has a magnitude of 8.1. It is one of the most complex planetary nebulas ever seen. There is a magnificent Hubble photo of this object.

There are 28 galaxies within this constellation listed in Sky Atlas 2000. A few of the brightest are listed below.

NGC 4125 - A bright, large elongated galaxy with a magnitude of 9.8.

NGC 4128 - A bright spindle shaped galaxy with a magnitude of 12.0.

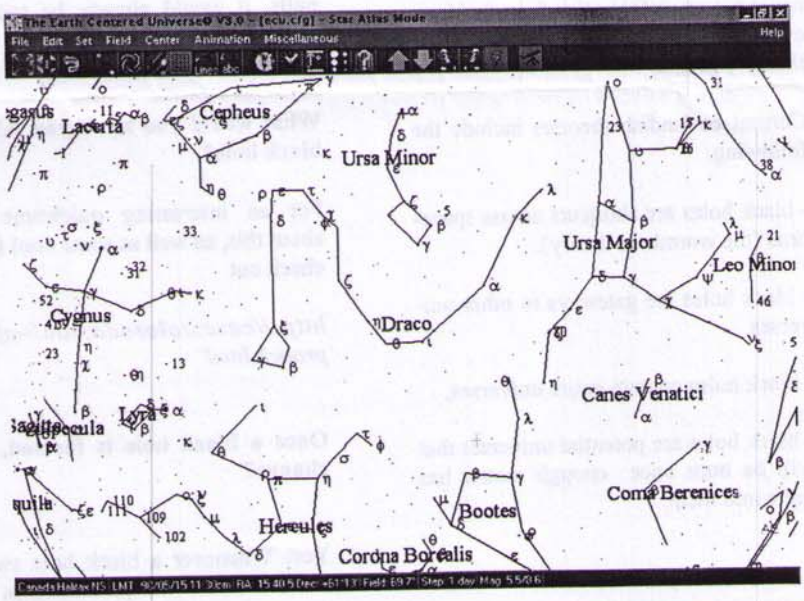
NGC 4256 - A bright, large, elongated edge on galaxy with a magnitude of 11.9.

NGC 4291/NGC 4319 - A pair of small, bright, round galaxies; magnitudes 11.8 and 11.9.

NGC 5866 - A bright, large, elongated, edge on Seyfert type galaxy with a magnitude of 10.0. This galaxy is one of two candidates for M102. (M101 is the other).

NGC 5907 - A bright, large elongated Seyfert type galaxy with a magnitude of 10.4.

NGC 5985 - A bright, large galaxy with many filamentary arms. Magnitude 11.0.



Stewart's Cool Web Sites!

Space Jokes:
http://www.open.hr/space/space/jokes.htm

Intro to Archeoastronomy:
http:/www.wam:umd.edu/~tlalloc/archastro/cfaar_as.html

The Neutrino Mass Story:
http://www.phys.hawaii.edu:80/~jgl/huosc_story.hlml

HAA Star Party - June 19-21

-Juliana Light

Here's a reminder that the HAA will hold its star party this year at Silent Lake Provincial Park, located on Highway 28, north of Peterborough.

Try to reserve your campsite as soon as possible by calling (613) 339-2807. Tell them you're with the HAA Star Party as it might make a difference as to which campsite you'll get. The fee is $17.75/night, plus a $6.00 reservation fee. You'll need to provide your credit card number to reserve, but you can pay by cash at the park when you arrive if you prefer.

For more information about Silent Lake, call the Ministry of Natural Resources at (416) 314-2000.

The nightly set-up location for our telescopes will be in the day-use area near the Park Office at the entrance to the park. Remember that you don't need a telescope to join in the fun!

If you have any questions, please contact:

Juliana Light or Ann Tekatch
Tel: (905) 846-8990
Tel: (905) 575-5433

E-mail: bx057@torfree.net
E-mail: tekatch@nas.net

Here's hoping the weather is good and the mosquitoes aren't bad. I hear John is bringing his guitar - wonderful!

The Hamilton Amateur Junior Astronomers met for the last time until September on Monday, May 25th. We had lots of fun this year discussing astronomy topics and completing astronomy related crafts. I would like to thank everyone for coming out to HAJA this year and I look forward to seeing everyone in September.

I would also like to thank Tracy for all her skilled help in the last couple of years. Unfortunately Tracy is moving to Toronto during the summer and will not be able to help coordinate HAJA in September. I won't be able to organize HAJA by myself, so if anyone is interested in helping out please contact me during the summer.

Rosa Assalone 540-8793
assalor@mcmaster.ca

Black Holes Cont ...

(Continued from page 1)
verse.

Do black holes lead anywhere ?

Who knows ?! By definition, we can never get any information from inside an event horizon, so make up any crazy theory you like.

Current outlandish theories include the following:

- black holes are shortcuts across space-time (the wormhole theory).

- black holes are gateways to other universes.

- black holes contain entire universes.

- black holes are potential universes that will be born once enough matter has gone into them.

If a black hole was really a gateway, could you go through it ?

Absolutely no way! The reason : differential gravitational forces.

Here's the explanation:

Most people don't realize it, but the Earth stretches us all just a little. By this I mean that the Earth pulls a little harder on our feet than on our heads simply because our feet are a little closer to the Earth's center.

Of course, the difference is so slight and we're so used to it, that this causes no problems whatsoever. But a black hole's gravity is so powerful that when you get near one, it does make a difference!

Say you're an engineer in the U.S.S. Enterprise and all of a sudden Picard informs you that the ship is dangerously close to a black hole. Now if you don't get the ship turned around right away, you'll start feeling pretty strange. Whatever part of you is closest to the black hole will be more strongly attracted to it than the other parts of you. If the ship stays on course, your body will be radially stretched until it gets torn apart by the difference in gravitational forces. Even the good old Enterprise will eventually be shredded.

The scary thing about this scenario is that unless the black hole was extremely massive, this stretching wouldn't be noticeable until you were already inside the event horizon. Thus, if you were feeling the differential gravitational pulls, it would already be too late to escape!

What would you see if you fell into a black hole?

For an interesting quicktime movie about this, as well as some cool facts, check out

http://casa.colorado.edu/~ajsh/approach.html

Once a black hole is formed, can it change?

Yes! Whenever a black hole swallows

(Continued on page 7)

Black Holes Cont ...

(Continued from page 6)
something, its event horizon grows and so does its gravitational pull.

So of course, the next question that arises is:

What keeps black holes from swallowing everything in the universe?

Well, unless a star or other object is really close to the black hole, it won't get sucked in. Planets orbit the sun without falling in, just as man-made satellites circle the Earth quite freely. Gravitationally, a black hole behaves just like the sun or the Earth, except when things get close to its event horizon. That's when things get hairy.

Also, there is an opposite effect that actually makes black holes shrink!

In empty space, pairs of subatomic particles are constantly forming out of energy fluctuations in the vacuum. Of this pair of particles, one is made of matter and one of antimatter. Usually, the minute these particles form, they collide and annihilate each other. But if the pair forms near a black hole, one particle might get sucked in before it has a chance to collide with its partner. The other particle escapes into outer space. Even though this is an incredibly tiny loss of mass, it happens a lot. Over time, astrophysicists theorize that it could cause a black hole to evaporate.

How can I go to find out more about black holes ?

Read chapters 10 and 11 in Stephen Hawking's "Black Holes and Baby Universes and Other Essays". Chat with other HAA people, especially the ones that you saw sucking up the most hamburgers at the last star party. Do a search on the web using keywords like **black hole**, **Schwarzschild radius**, **gravity waves**, **gravitational lensing**, and of course **event horizon**.

Or send me email. Really, I mean it.

Movie Review - Lost In Space

-Denise Kaisler

Last Sunday, I went out with a bunch of friends to see Lost In Space, the latest Sci-Fi flick to hit Korea. I'd seen a few episodes of the original series on MuchMusic and figured that the movie would be funny and well aware of its own campiness.

However, after the first half hour I was searching the back of the seat in front of me for one of those handy airsickness bags.

Not only was the dialogue insipid and the plot corny, but the movie showed a total disregard for natural laws. In the first 10 minutes, I saw enough physics bloopers to let me know that nobody in Hollywood would recognize Newton - even if he came up and bit them !

Here's a list of things that had me tearing out my hair in the theatre :

1) Explosions in outer space

Sorry movie moguls, but this can't happen. An explosion needs oxygen to fuel it. In hard vacuum there might be a few atoms of hydrogen per cubic centimeter, but certainly not enough oxygen to sustain those blooming red-orange clouds.

Plus, not only was I treated to the sight of these explosions, but to their sound as well. Shoot, guys, every high-school senior is supposed to know that sound waves are the compressions of a medium such as air or water. You can't hear sound in a vacuum because there isn't enough stuff to carry a sound wave !

2) Spaceships shooting laser beams at each other.

While this is admittedly possible, you wouldn't be able to see the laser beams streak across the blackness. Laser light isn't visible unless there are some kind of particles around to reflect it. At laser shows, the technicians provide smoke, steam from dry ice, or project the lasers onto a wall. In vacuum, you wouldn't see anything. And to tell you the truth, I think that would make for a much more effective weapon.

3) Starfighters that look as if they're made of glass.

Come on ! Space full of deadly radiation - UV light, X-rays, gamma rays, and cosmic rays (tiny particles traveling at very high speeds). On Earth, we're protected from most of this gunk by the ozone layer, but ships with transparent walls would leave their dashing young pilots vulnerable to all of it. Not only that, what about the tiny chunks of ice and rock that are left in the wake of comets - the kinds that cause meteor showers on earth? At supersonic speeds, a mere pebble could penetrate those flimsy shells.

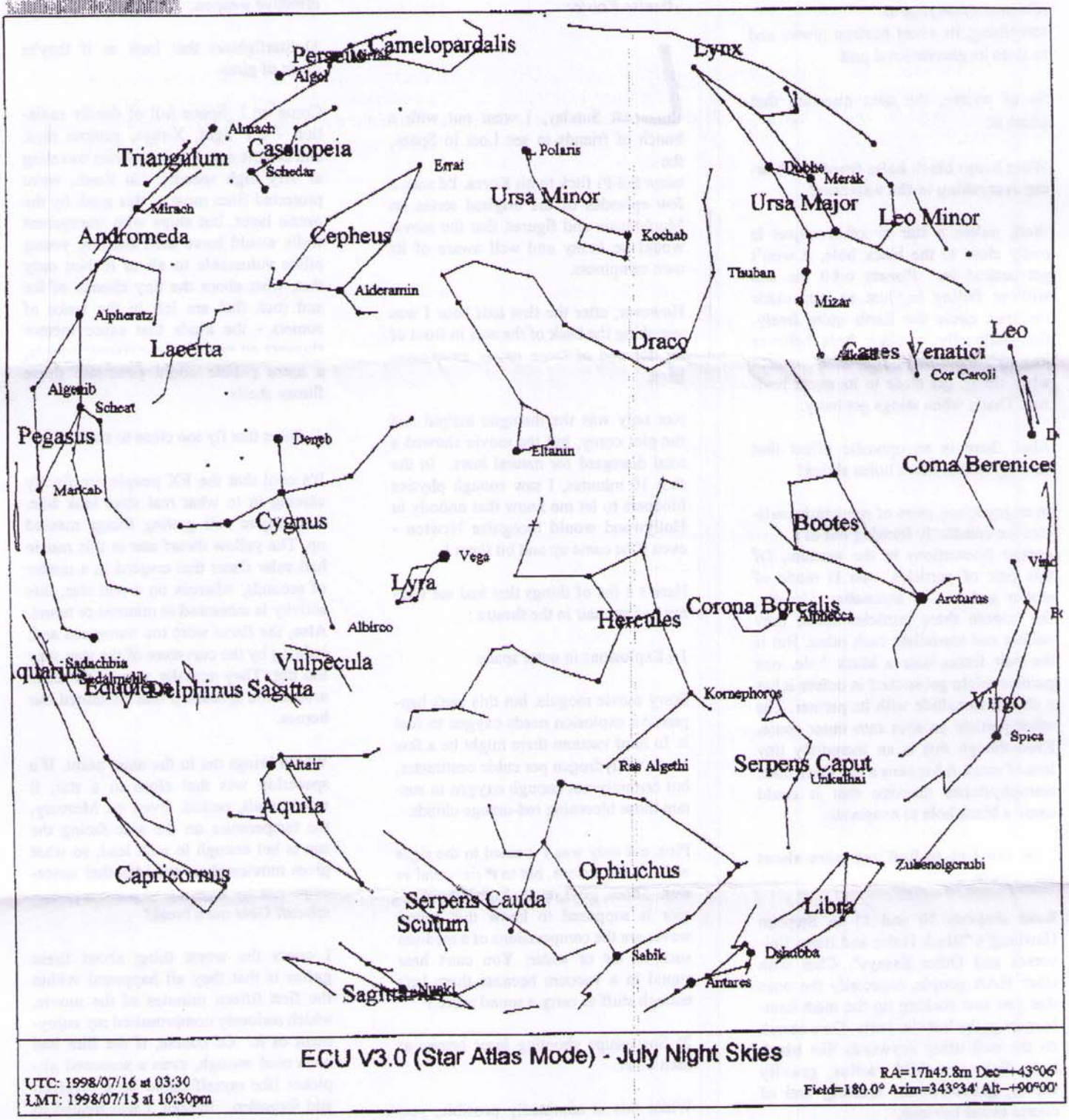
4) Ships that fly too close to stars

It's cool that the FX people are finally clueing in to what real stars look like. But they're still getting things messed up. The yellow dwarf star in this movie had solar flares that erupted in a matter of seconds, whereas on a real star, this activity is measured in minutes or hours. Also, the flares were too numerous and, judging by the curvature of the star, way too big. They actually seemed to reach around the spaceship that contained our heroes.

Which brings me to the main point. If a spaceship was that close to a star, it would melt, period. Even on Mercury, the temperature on the side facing the sun is hot enough to melt lead, so what gives moviemakers the idea that spaceships can fly right up to a star's photosphere? Give me a break!

I guess the worst thing about these gaffes is that they all happened within the first fifteen minutes of the movie, which seriously compromised my enjoyment of it. Of course, if the film had been cool enough, even a seasoned nitpicker like myself could have forgiven and forgotten. Instead, I was treated to stilted acting, a choppy, insubstantial plot, and a horribly saccharine ending. I guess maybe physics was the *least* of the movie's problems.

July Night Skies



Hamilton Amateur Astronomers Sweatshirts and T-Shirts!

We will soon be placing an order for sweatshirts and t-shirts! Unfortunately, due to a technical problem with the graphic for Doug's scenic desgin, we can't proceed with the oatmeal shirts just yet. We have decided to go ahead with the new, round logo design for now.The new logo will be done in blue & gold and is available on either a forest green or navy blue sweatshirt. It is also available on a t-shirt, but only in forest green. To order your shirt, please complete the form below and return it with your payment (cheques payable to "Hamilton Amateur Astronomers") to:

Ann Tekatch
19 Pheasant Place
Hamilton, ON L9A 4Y4

Shirts will be ordered as soon as the number of orders justifies it. I will contact you by phone and/or email when the shirts arrive.

ORDER FORM

NAME: _____

ADDRESS: _____

PHONE: _____

EMAIL ADDRESS: _____

SWEATSHIRT (NUMBER __)

Colour: Green
Blue

Size: Small
Medium
Large
X-Large

T-SHIRT (NUMBER __)

Size: Small
Medium
Large
X-Large

Sweatshirts: $22. each (includes taxes)
T-shirts: $10. each (includes taxes)

Calendar of Events

- **June 19-21** Hamilton Amateur Astronomers Star Party
- **July 24-26** North Bay *AND* Huronia Star Parties
- **August 14-16** Syracuse Star Party
- **August 23-26** Starfest!
- **September 11 7:30 pm** Hamilton Amateur Astronomers General Meeting - At the Hamilton Spectator Building