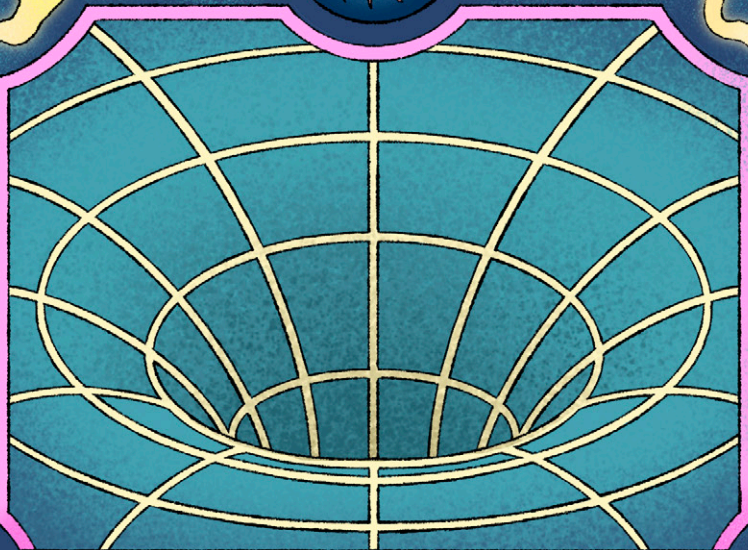
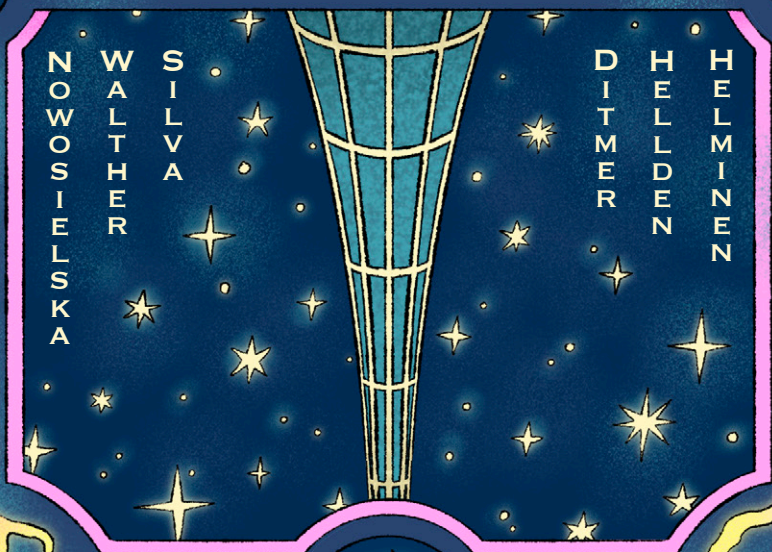




• BLACK HOLES •

SILVA
WALTHER
NOWOSIELSKA

HELLMINKEN
DITMER



BLACK HOLE • COMIC BOOK •

A collaborative public outreach comic book project
between students at the Graphic Storytelling
Workshop at TAW and scientists at the Center of
Gravity at Niels Bohr Institute.

Written and illustrated by

Anna Helminen
Giorgina Walther
Leonor Silva
Pelle Ditmer
Freja Ytting Helldén
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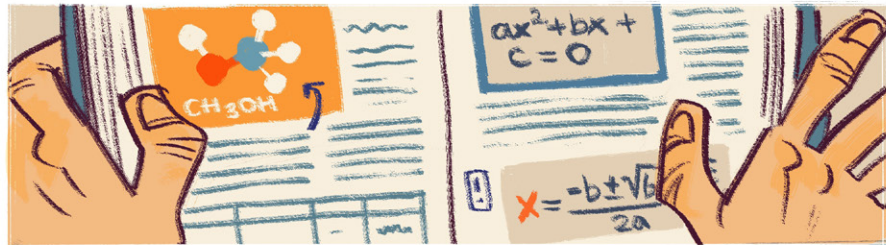
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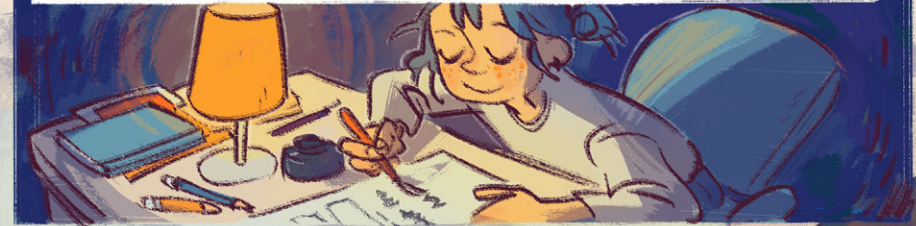
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HOWEVER, SOMEWHERE ALONG THE WAY I DEVELOPED WHAT I MISTAKENLY THOUGHT OF AS AN UNDERSTANDING OF SCIENTIFIC CONCEPTS.



IT WOULD BE FOOLISH OF ME TO CLAIM, THAT I HAVE NOW GAINED AN UNDERSTANDING ON THESE MATTERS, BUT I'D SAY IT'S WORTH SOMETHING TO KNOW HOW RIDICULOUSLY WRONG YOU USED TO BE.



SO JUST TO MAKE YOU, MY FELLOW NON-SCIENCE BRAINED HUMAN, FEEL SLIGHTLY MORE UNDERSTOOD AND LESS RIDICULOUS ABOUT YOURSELF, MAY I PRESENT:



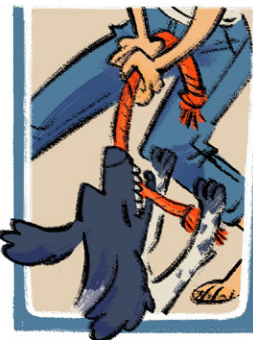
GRAVITY

I THOUGHT GRAVITY WAS SOMETHING LIKE A MAGNET, RESIDING DEEP WITHIN THE EARTH, AS A PART OF THE PLANETS CORE. I FIGURED THAT'S WHY EVERYTHING ALWAYS FELL TOWARDS THE GROUND, AND WE ALL DIDN'T JUST FLOAT AWAY INTO SPACE.

I'VE NOW BEEN INFORMED, THAT IN ACTUALITY, ALL THINGS HAVE THEIR OWN GRAVITATIONAL FIELD, INCLUDING HUMANS, DOGS AND EVEN A SMALL APPLE.

AND THE BIGGER THE OBJECT, THE STRONGER THE GRAVITATIONAL FIELD.

AND AS ALL OBJECTS ARE PULLED TOWARDS ONE ANOTHER, IT IS AS IF WE ARE ALL HAVING AN INVISIBLE TUG OF WAR.

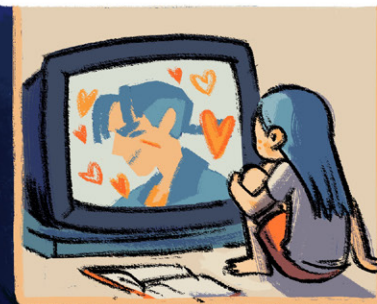


do not try this at home

ANOTHER THING I HAD A WONKY IDEA ABOUT WAS

BLACK HOLES

BUT THIS ONE I MAINLY BLAME ON MY OVERACTIVE IMAGINATION AS A CHILD AND THE DISNEY FILM TREASURE PLANET.



HOWEVER, WHAT I THOUGHT A BLACK HOLE TO BE, WAS A HOLE IN THE SPACE, LIKE A FOREVER POWERED VACUUM CLEANER SUCKING EVERYTHING IN.

VERY APOCALYPTIC OF ME, ISN'T IT?

We're doomed!

OH NO!



IN TRUTH, THE HOLE IS NOT JUST IN SPACE, BUT IN BOTH SPACE AND TIME, ALSO KNOWN AS SPACETIME.



WORDS WE'VE ALL HEARD WHILE BINGEING STAR TREK TURN OUT TO BE SEATED IN REALITY. WHO KNEW?

ALSO, IT'S NOT QUITE AS WORLD-ENDING A MATTER AS IT HAD BECOME IN MY HEAD.



IN REALITY, ONE CAN ONLY BE DRAGGED INTO A BLACK HOLE IF ONE PASSES ITS EVENT HORIZON.



IT'S ONLY AFTER CROSSING THAT FINAL TRESHOLD THAT THERE'S NO COMING BACK.

IT WAS DESCRIBED TO ME AS IF A CHILD WAS ABOUT TO GO DOWN A SLIDE AT THE PARK: THERE'S A MOMENT WHEN SCOOTCHING, AFTER WHICH THEY CANNOT HELP BUT SLIDE DOWN.

THE THIRD SUBJECT I HAD SEVERELY MISUNDERSTOOD WAS

GRAVITATIONAL WAVES

IN MY DEFENSE, ANYONE NOT NECK DEEP IN SCIENCE WOULD THINK THESE TO BE A FANCY SYNONYM FOR AN EARTHQUAKE... RIGHT?



IN ACTUALITY, GRAVITATIONAL WAVES ARE A CURVATURE IN SPACETIME PRODUCED BY EVERYTHING THAT HAS A GRAVITATIONAL FIELD - SOMETHING WE DETERMINED ALL OBJECTS HAVE A FEW PAGES BACK.

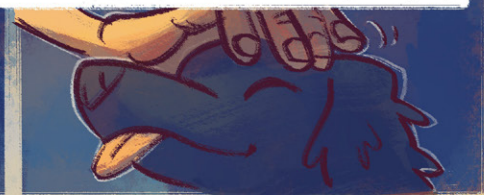
IT'S LIKE WE ARE ALL SENDING INVISIBLE, TEENY TINY RIPPLES, SPACETIMEQUAKES IF YOU WILL, TO THE FABRIC OF REALITY JUST BY EXISTING.

THERE'S PROBABLY DOZENS OF OTHER THINGS I HAVE MISUNDERSTOOD.



I CAN'T WAIT TO FIGURE OUT, WHAT THEY ARE.

FUNNILY ENOUGH THOUGH, THAT IS EXACTLY HOW SCIENTIFIC FINDS HAVE HAPPENED THROUGHOUT OUR EXISTENCE.



AND I GUESS THAT'S MY FINAL MISUNDERSTANDING:

Science is still exploratory.
It's not "done" nor can it ever be.
Even the best explanation is still just the current understanding.

AND APPARENTLY, WHEN IT COMES TO SCIENCE, THE MATTER IS ALWAYS SLIGHTLY MORE COMPLICATED THAN WHAT IT FIRST SEEMS.



KARL SCHWARZSCHILD

GIORGINA WALTHER

What most people remember when learning about black holes is how nothing that enters a black hole's vicinity can ever escape it, not even light.

Scientists call this point of no return the 'event horizon', a point where gravity is so strong that the escape velocity equals the speed of light, subsequently trapping everything - including light - inside. The typical size of the event horizon is given by the Schwarzschild Radius.

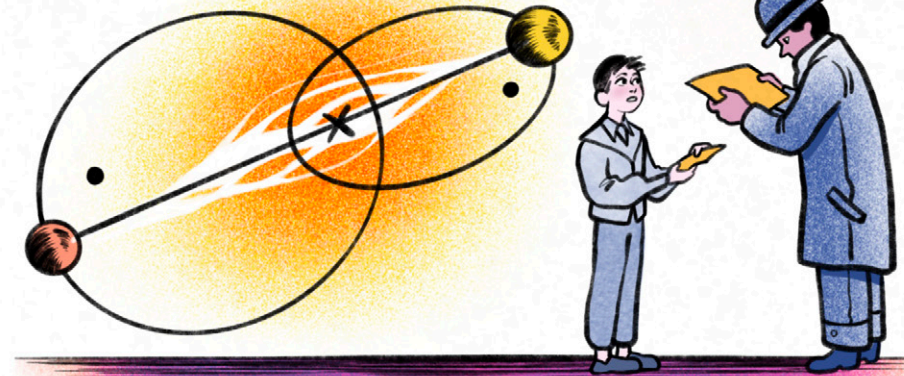
But do you know about the person who has discovered the Schwarzschild radius?



Born in 1873 in Frankfurt am Main in Germany to Jewish parents, Karl Schwarzschild had an early interest in astrophysics and was considered a child prodigy.

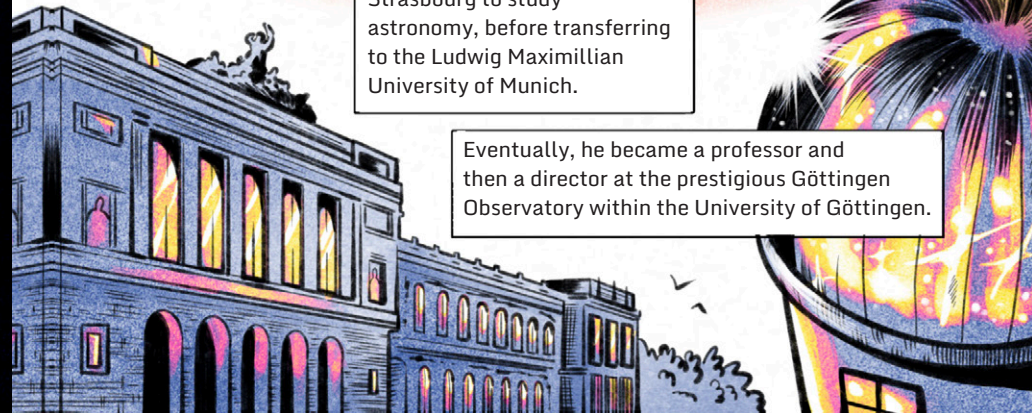


By age sixteen, he had already published two papers on binary orbits.



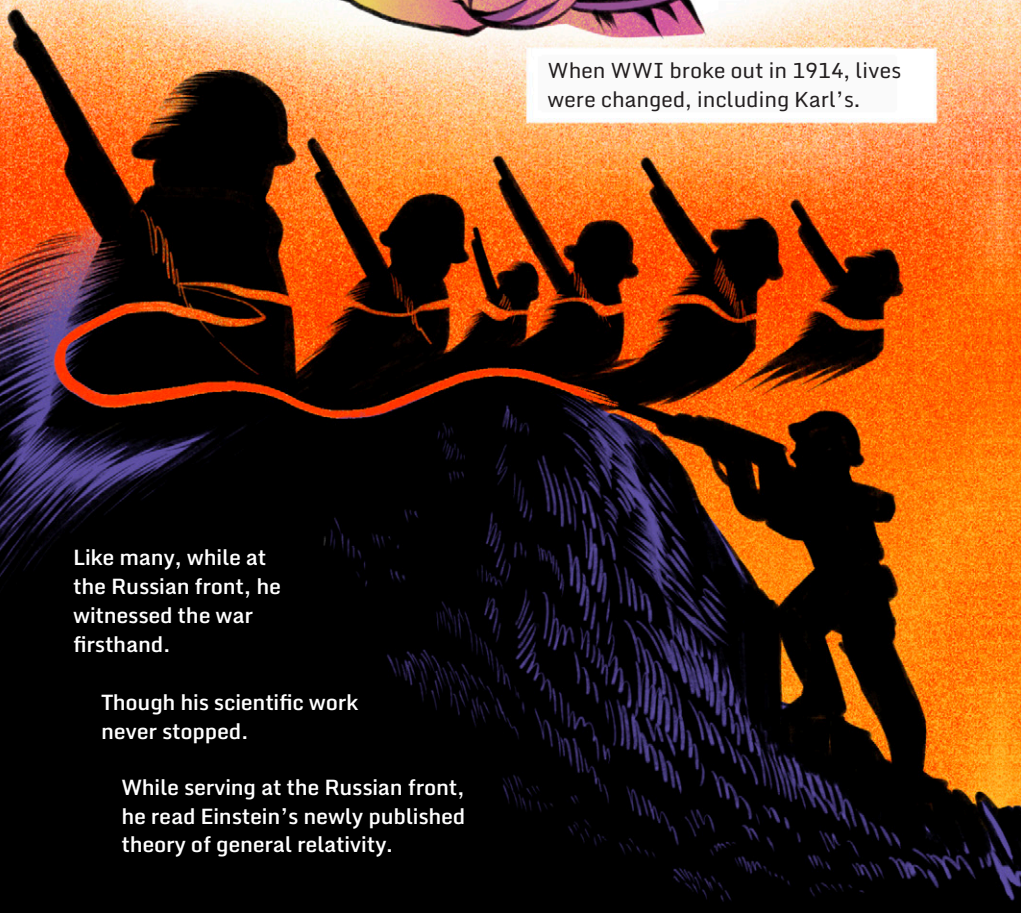
He attended the University of Strasbourg to study astronomy, before transferring to the Ludwig Maximilian University of Munich.

Eventually, he became a professor and then a director at the prestigious Göttingen Observatory within the University of Göttingen.





Later Karl moved with his wife Else Rosenbach to Potsdam, where he worked as a director of the Astrophysical Observatory.



When WWI broke out in 1914, lives were changed, including Karl's.

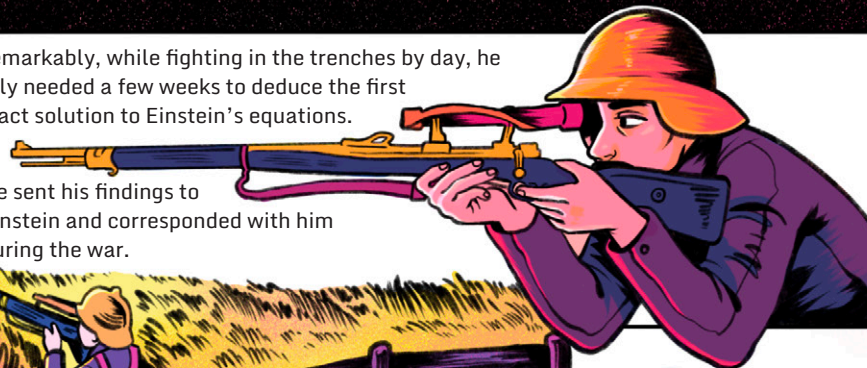
Like many, while at the Russian front, he witnessed the war firsthand.

Though his scientific work never stopped.

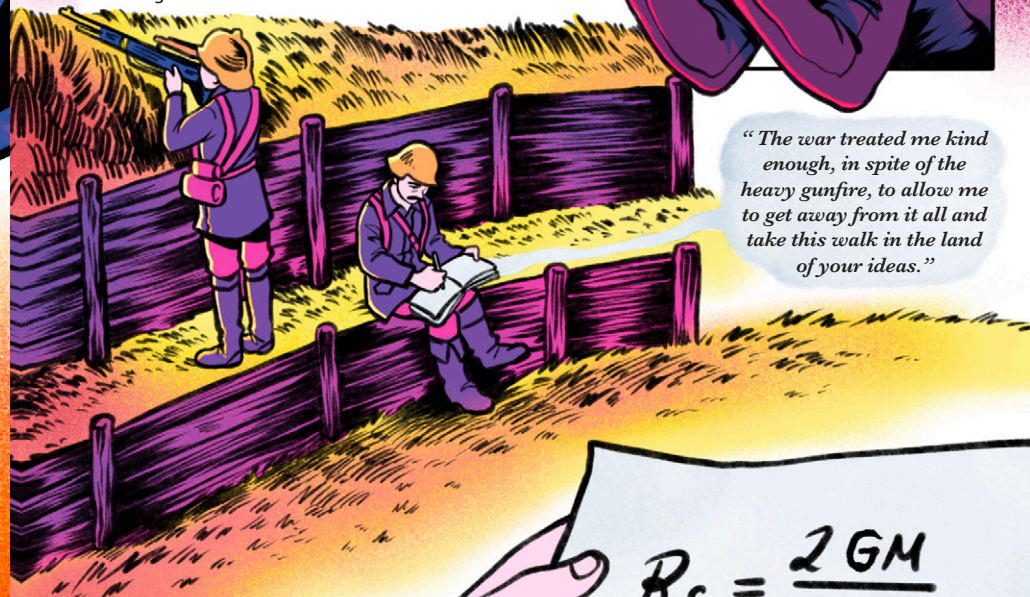
While serving at the Russian front, he read Einstein's newly published theory of general relativity.

Remarkably, while fighting in the trenches by day, he only needed a few weeks to deduce the first exact solution to Einstein's equations.

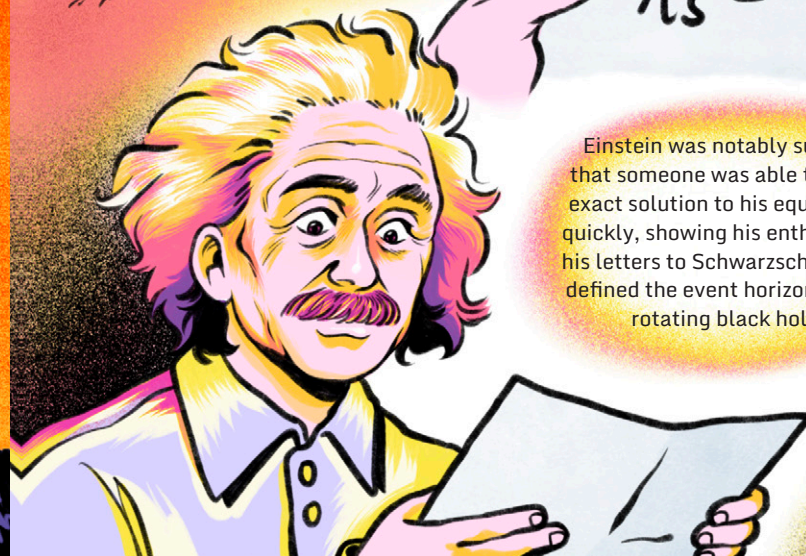
He sent his findings to Einstein and corresponded with him during the war.



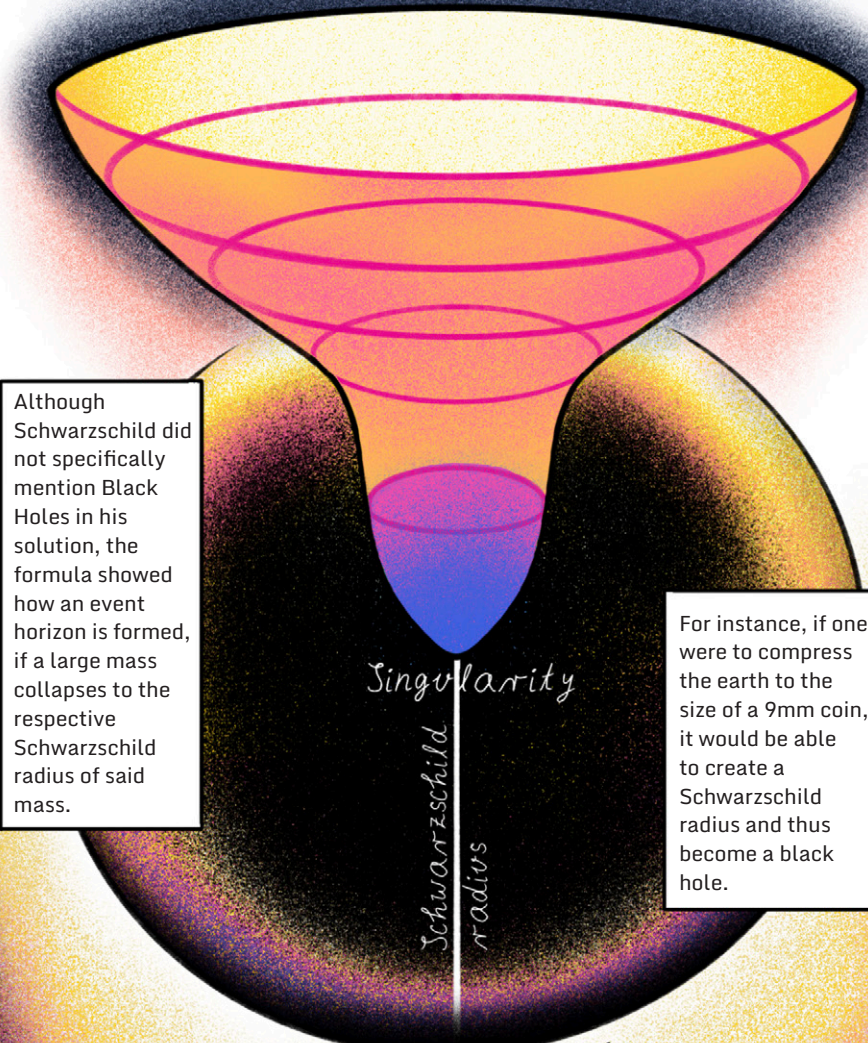
"The war treated me kind enough, in spite of the heavy gunfire, to allow me to get away from it all and take this walk in the land of your ideas."



$$R_s = \frac{2GM}{c^2}$$



Einstein was notably surprised that someone was able to find an exact solution to his equations so quickly, showing his enthusiasm in his letters to Schwarzschild, which defined the event horizon for non-rotating black holes.



Although Schwarzschild did not specifically mention Black Holes in his solution, the formula showed how an event horizon is formed, if a large mass collapses to the respective Schwarzschild radius of said mass.

For instance, if one were to compress the earth to the size of a 9mm coin, it would be able to create a Schwarzschild radius and thus become a black hole.

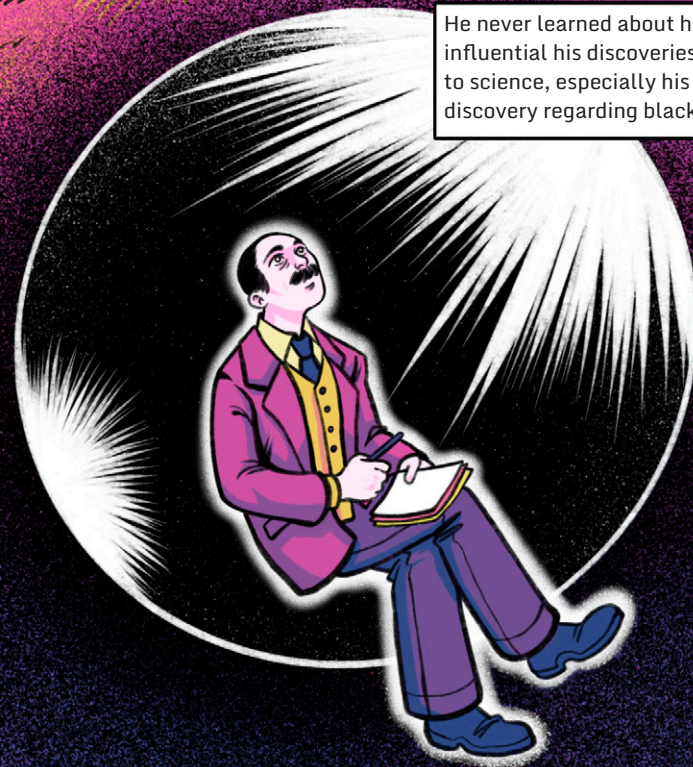
So in theory, anything can become a black hole,

The sun, your cat and even you.



Unfortunately, Karl Schwarzschild died from an autoimmune disease that he most likely developed on the battlefield.

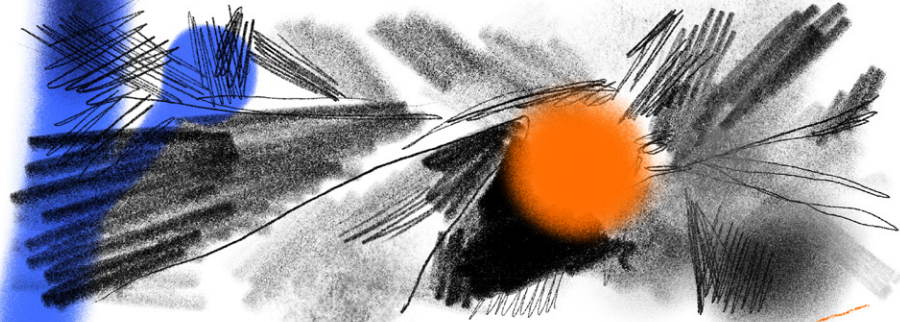
He never learned about how influential his discoveries were to science, especially his discovery regarding black holes.



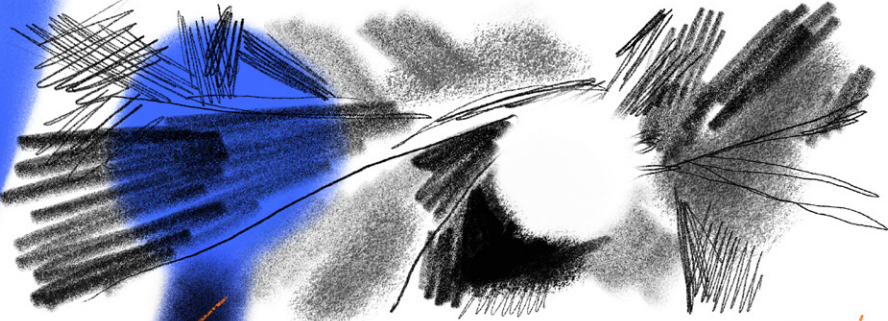
HOW DO BLACK HOLES FORM?

BY LEONOR SILVA

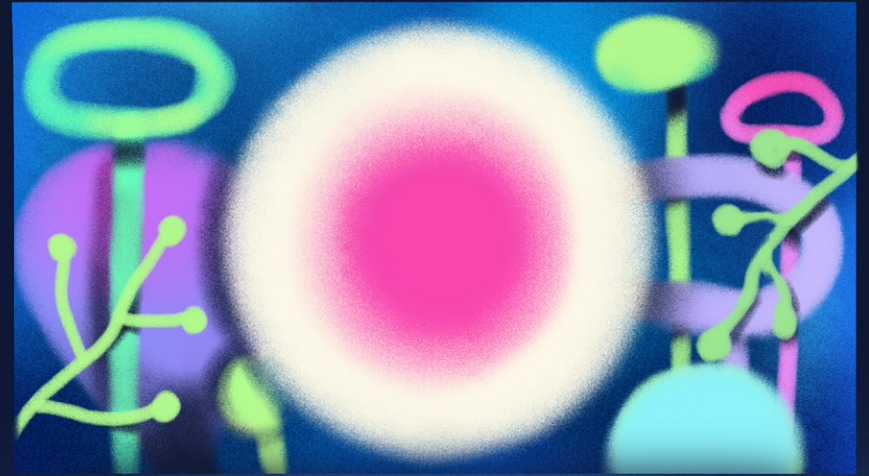
YOU SURE HAVE HEARD ABOUT THE FABRIC OF SPACE TIME,
I IMAGINE IT AS MY BED. AND I LIKE TO THINK OF A STAR AS A BODY,



A BODY WITH MASS AND DENSITY. ITS GRAVITY WEIGHS ON THE BEDSHEETS,
DEFORMING THEM, LEAVING MARKS OF ITS PRESENCE IN THE FABRIC.



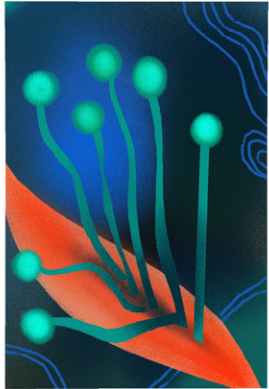
THIS BODY HAS AT ITS CORE, A BEATING HEART WE CALL A NUCLEUS.
HERE IT'S SO DENSE AND WARM THAT THE ATOMS THAT FORM THE BODY FUSE,
ENERGY IS RELEASED.



RADIATION FIGHTS AGAINST THE PRESSURE OF GRAVITY, AS LONG AS THIS IS
BALANCED, THE NUCLEUS IS STABLE.



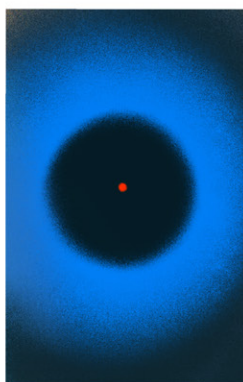
THROUGH THE FUSION OF THE ATOMS INSIDE THE NUCLEUS,
NEW ELEMENTS ARE CREATED. THIS IS THE ORIGIN OF EVERYTHING THERE IS



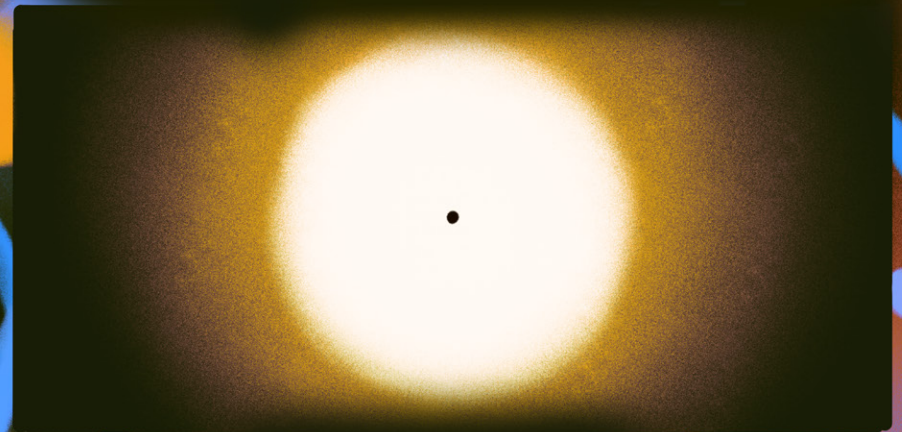
FROM HYDROGEN TO HELIUM. HELIUM TO CARBON. CARBON TO OXYGEN.



AND FROM THESE, EVEN HEAVIER ELEMENTS ARE BORN. UNTIL IT REACHES IRON.



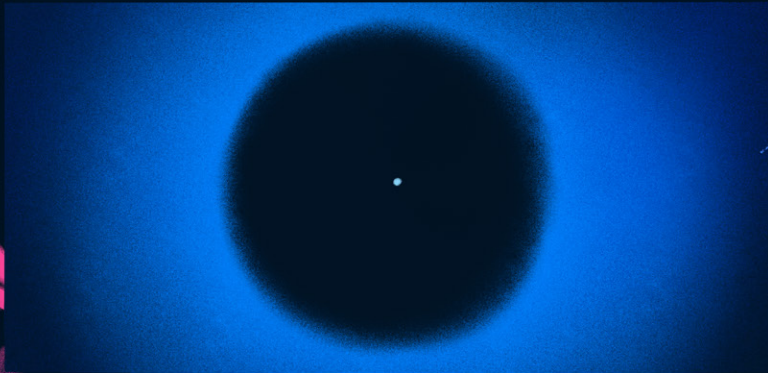
WITH THIS LAST FUSION, THE ENERGY RADIATED IS LOWER, THE BODY GETS COLDER,
THE BALANCE IS BROKEN. GRAVITY MEETS NO MORE RESISTANCE,
SO ITS PRESSURE BECOMES UNBEARABLE.



THE NUCLEUS COLLAPSES ON ITSELF.



A NUCLEUS COLLAPSING MEANS ITS MASS BECOMES CONCENTRATED IN A SMALLER SIZE.



IF THE DENSITY OF THE BODY IS HIGH ENOUGH, IT CURVES THE FABRIC OF SPACETIME, CONVERGING TO A SINGLE POINT. THE NUCLEUS BECOMES A SINGULARITY.

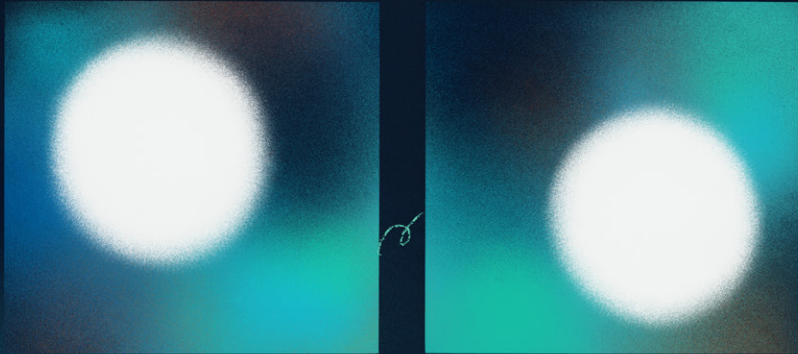


THIS BODY HAS NO HARD SURFACES, JUST AN EVENT HORIZON, FROM WHERE NOTHING ESCAPES, ONCE WE CROSS IT.



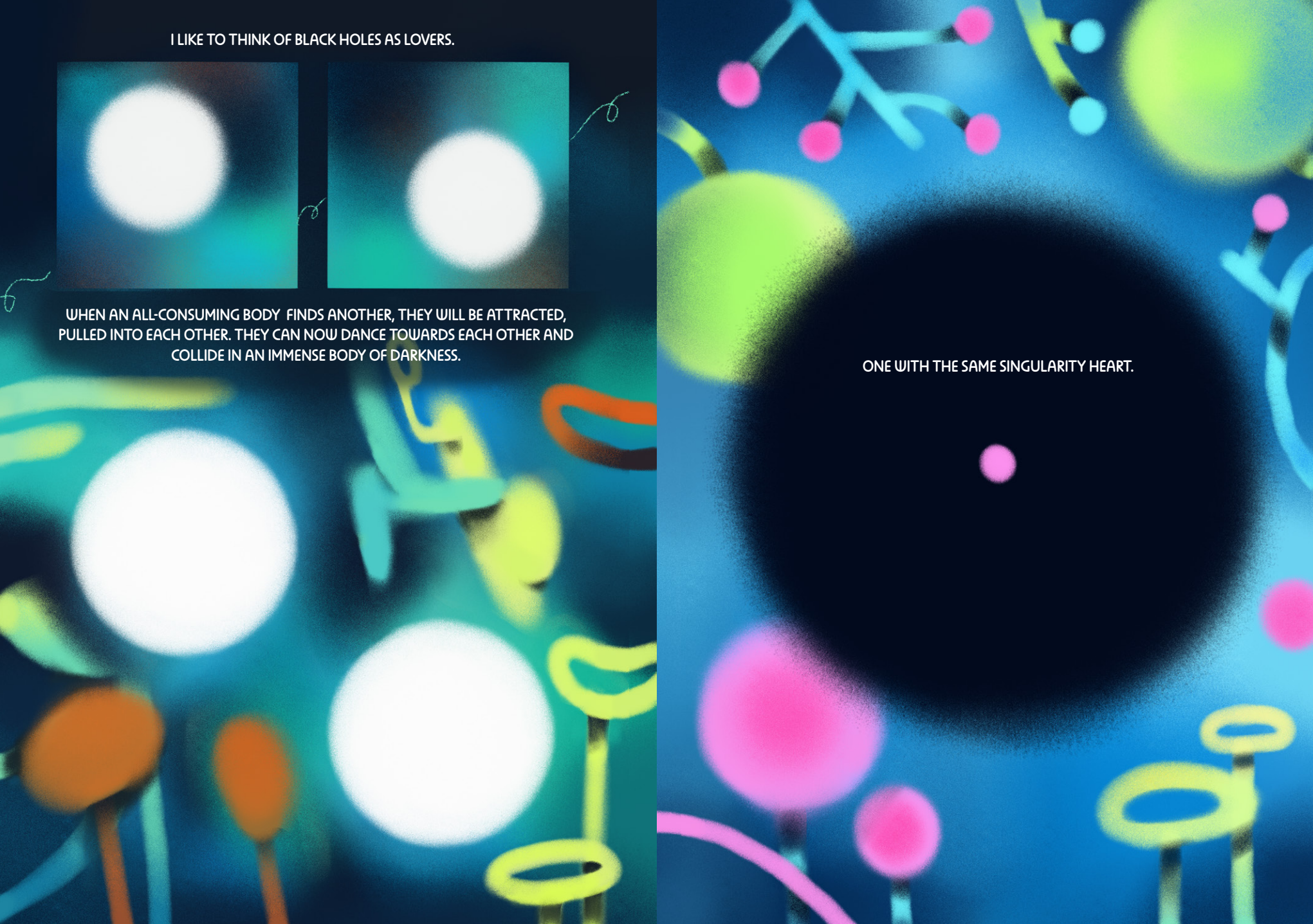
IT SWALLOWS EVERYTHING AROUND IT, GETTING DENSER AND DENSER

I LIKE TO THINK OF BLACK HOLES AS LOVERS.



WHEN AN ALL-CONSUMING BODY FINDS ANOTHER, THEY WILL BE ATTRACTED,
PULLED INTO EACH OTHER. THEY CAN NOW DANCE TOWARDS EACH OTHER AND
COLLIDE IN AN IMMENSE BODY OF DARKNESS.

ONE WITH THE SAME SINGULARITY HEART.

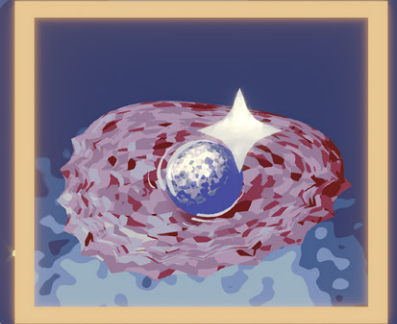
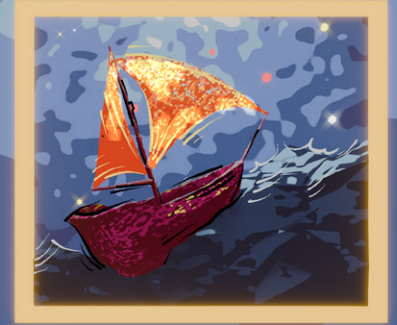


BLACK PEARLS

by Pelle Ditmer

We drift through an ocean of gravity
on our vessel named Earth, peering up
at pearl-like stars, floating along
in the void.

When it comes to finding these pearls, we rely
on astronomers, mathematicians and physicists.
Our best fishermen.



But for decades they have speculated and
theorized about a more rare and elusive jewel.
A black hole. But how do you find a void-
colored pearl in a sea of cosmic pitch.





Entire swaths of space are caught in the cataclysm, forming 'Radio Lobes'.

Plasma, magnetic fields and relativistic electrons all encased in bubbles millions of lightyears across.

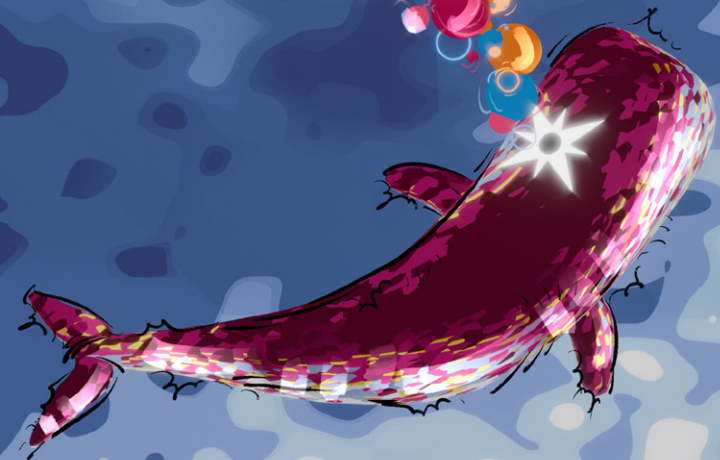
What frightful force could cause this?

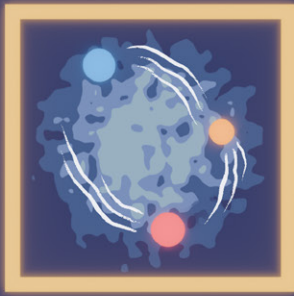
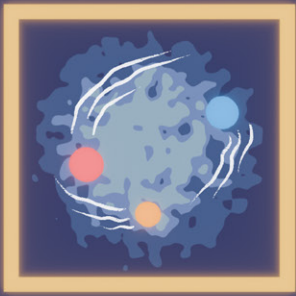
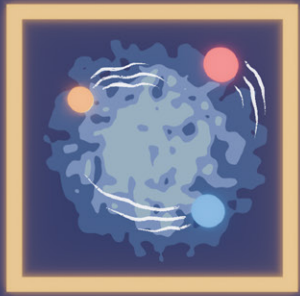
Is the black hole truly a pearl, or perhaps a black beast?
A wild whale, eluding our fishermen?

The starry seas boil...

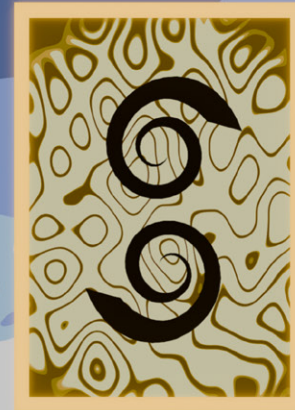
At first, these pearls hide behind immense spouts of light, so much like stars that they became known as 'Quasars' or 'Quasi-stellar Objects'.

But this is not starlight, but massive jets of superheated plasma, cast through the cosmic ocean across billions of light-years before reaching us and illuminating our waters.





When two of these vortices meet in the void, and swim around each other, the ripples can be felt across the vast ocean.



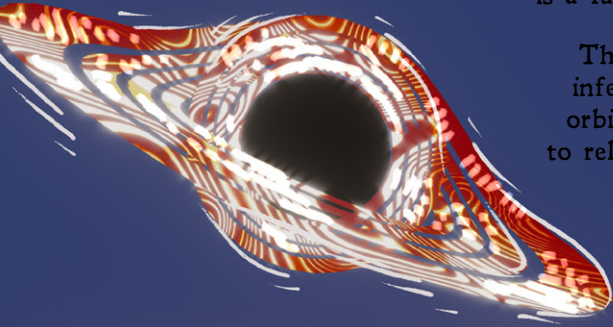
And our fishermen measure these ripples on the surface. Gravitational waves telling us of the sheer force of the pearls. Beasts, dancing in the deep.



Another way to find them is patience. By focusing all their attention and equipment on a region of space for years and years, slowly a pattern is revealed.

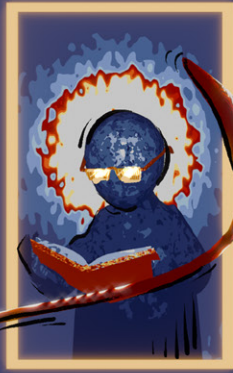
Stars swimming around an unseen force. Fish caught in a maelstrom of gravity.

Surrounding the black pearl,
is a luminous shell.



The accretion disc. A swirling
inferno at the innermost stable
orbit. Plasmic cinders, propelled
to relativistic speeds and thousands
of kelvin by the force
of the black hole.

Raging chaos near a
ravenous nothing.



Through the combined
efforts of our astronomers,
mathematicians and physicists,
we finally captured an image
of the disc near the
black hole at the
center of our
galaxy.

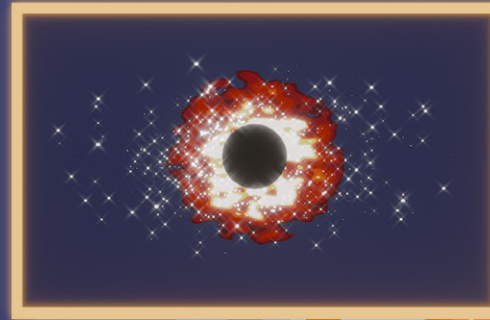
A beast, grasping at us with tendrils
of gluttonous gravity, pulling towards
a gaping maw.

Everywhere across the dark
ocean, pairs of particles form,
collide and annihilate.



Yet here, at the edge of
the unknown, unfortunate
pairs get split apart.

One is swallowed, while
the other flies outwards,
as though emanating from
the black hole. Hawking
radiation. This eats away
at the pit, but it is
unfathomably slowly.



The black hole,
the beast,
the pearl...

...will remain for
an incalculable age.

GRAVITATIONAL WAVES

FREJA YTING HELDÉN

IN 1915
ALBERT EINSTEIN
FORMULATED GENERAL
RELATIVITY.

OBJECTS WITH
MASS DISTORT
SPACETIME.

THAT IS HOW
WE UNDERSTAND
GRAVITY.

EINSTEIN
ALSO PREDICTED
GRAVITATIONAL
WAVES.

IF OBJECTS
ACCELERATE,

THEIR
GRAVITATIONAL
FIELDS WILL
FOLLOW,

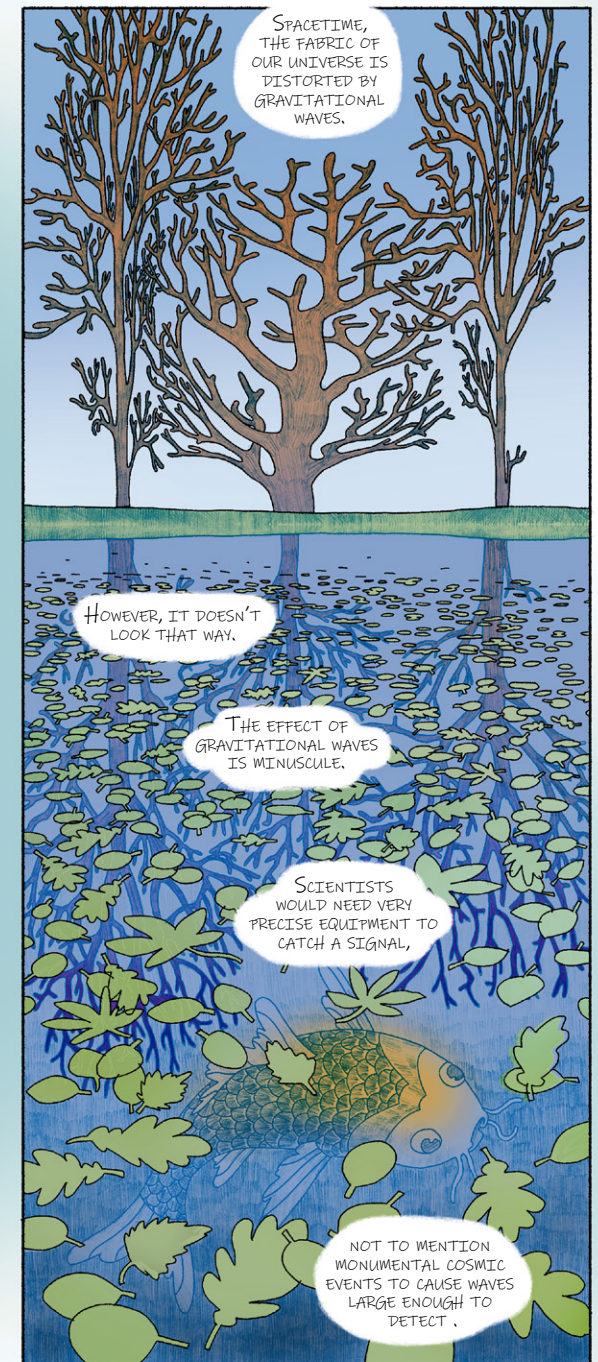
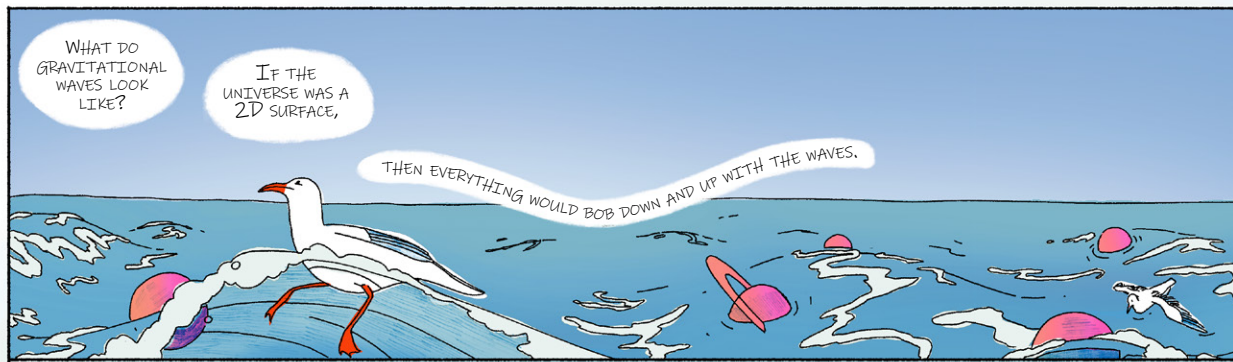
WITH
VERY SUBTLE
DELAY.

CERTAIN
MOVEMENTS CAUSE
RIPPLES IN SPACE-
TIME.

GRAVITATIONAL WAVES TRAVEL THROUGH THE UNIVERSE
AT THE SPEED OF LIGHT

INVISIBLE AND UNDETECTABLE

FOR ANOTHER 100 YEARS.



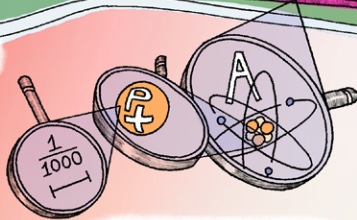
GRAVITATIONAL WAVE OBSERVATORIES

TO OBSERVE TINY DISTORTIONS IN SPACETIME, AN OBSERVATORY USES A LASER INTERFEROMETER WITH 3-4 KM. LONG ARMS AND A CAREFULLY TIMED LASER.

IF GRAVITATIONAL WAVES PASS BY EARTH, THE ARMS WILL BE STRETCHED AND SQUASHED EVER SO SLIGHTLY.

THIS IS HARD TO PICK UP EVEN WITH VERY SENSITIVE METHODS.

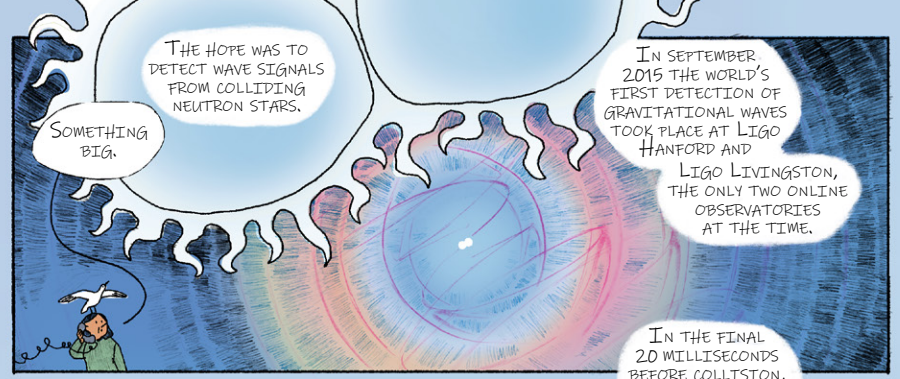
ON A 4KM. ARM WE WOULD BE LOOKING FOR A DISTORTION THE SIZE OF A TINY FRACTION OF A PROTON.



HAVING MULTIPLE OBSERVATORIES IS HELPFUL TO TELL APART LOCAL DISTURBANCES FROM GENUINE RESULTS.



NOW WE JUST NEED...



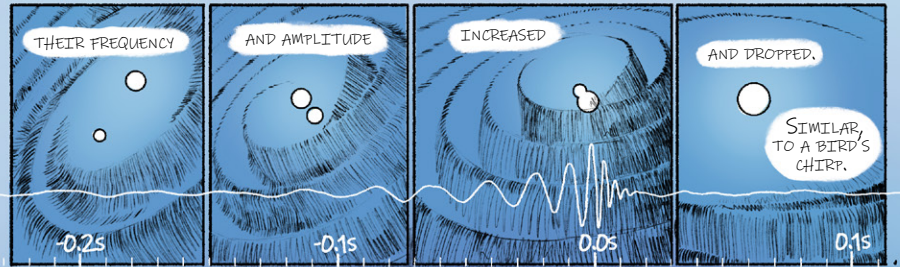
THE HOPE WAS TO DETECT WAVE SIGNALS FROM COLLIDING NEUTRON STARS.

SOMETHING BIG.

IN SEPTEMBER 2015 THE WORLD'S FIRST DETECTION OF GRAVITATIONAL WAVES TOOK PLACE AT LIGO HANFORD AND

LIGO LIVINGSTON, THE ONLY TWO ONLINE OBSERVATORIES AT THE TIME.

IN THE FINAL 20 MILLISECONDS BEFORE COLLISION, THE WAVES ROSE TO A DETECTABLE LEVEL.



CHIRP.

THAT WAS NOT NEUTRON STARS.

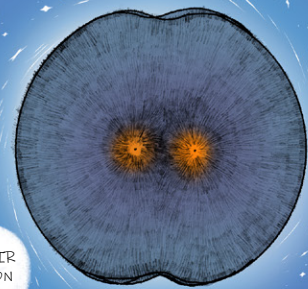
THE OBJECTS HAD ACCELERATED TO 60% OF LIGHT SPEED RIGHT BEFORE MERGING.

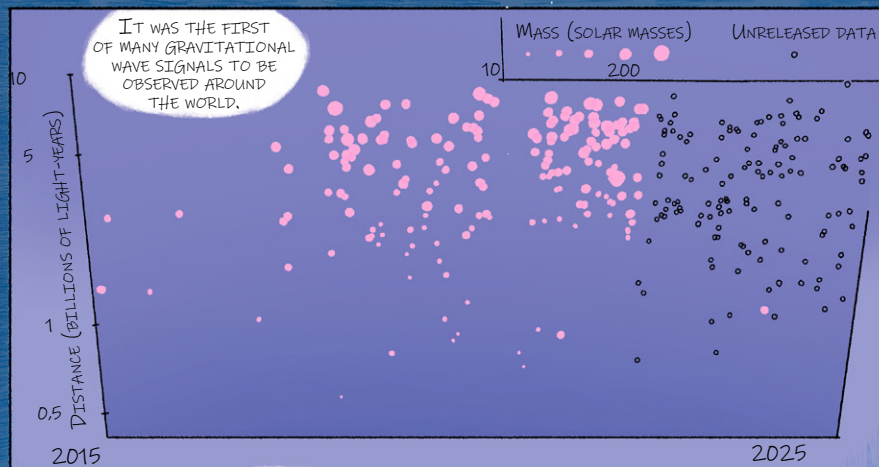
NEUTRON STARS CANNOT GO CLOSE ENOUGH TO EACH OTHER TO ORBIT AT SUCH HIGH VELOCITIES - THEY WOULD TOUCH AND MERGE BEFORE THAT.

ONLY BLACK HOLES CAN DO IT, DUE TO THEIR SMALL SIZE IN RELATION TO THEIR EXTREME MASS.

TWO BLACK HOLES, BOTH 30 TIMES THE MASS OF THE SUN, HAD MERGED INTO ONE MASSIVE BLACK HOLE.

THEY COLLIDED MORE THAN A BILLION LIGHT-YEARS AWAY, THUS OVER A BILLION YEARS AGO.





A WHOLE NEW METHOD TO FIND BLACK HOLES,

AND THE OBSERVATORIES KEEP ADVANCING, DETECTING MORE SIGNALS,

HELPING UNCOVER SOME OF THE GREATEST MYSTERIES OF THE UNIVERSE.

HOW CAN WE REACH EVEN FURTHER?

WHAT IF THE LASER INTERFEROMETER WAS...

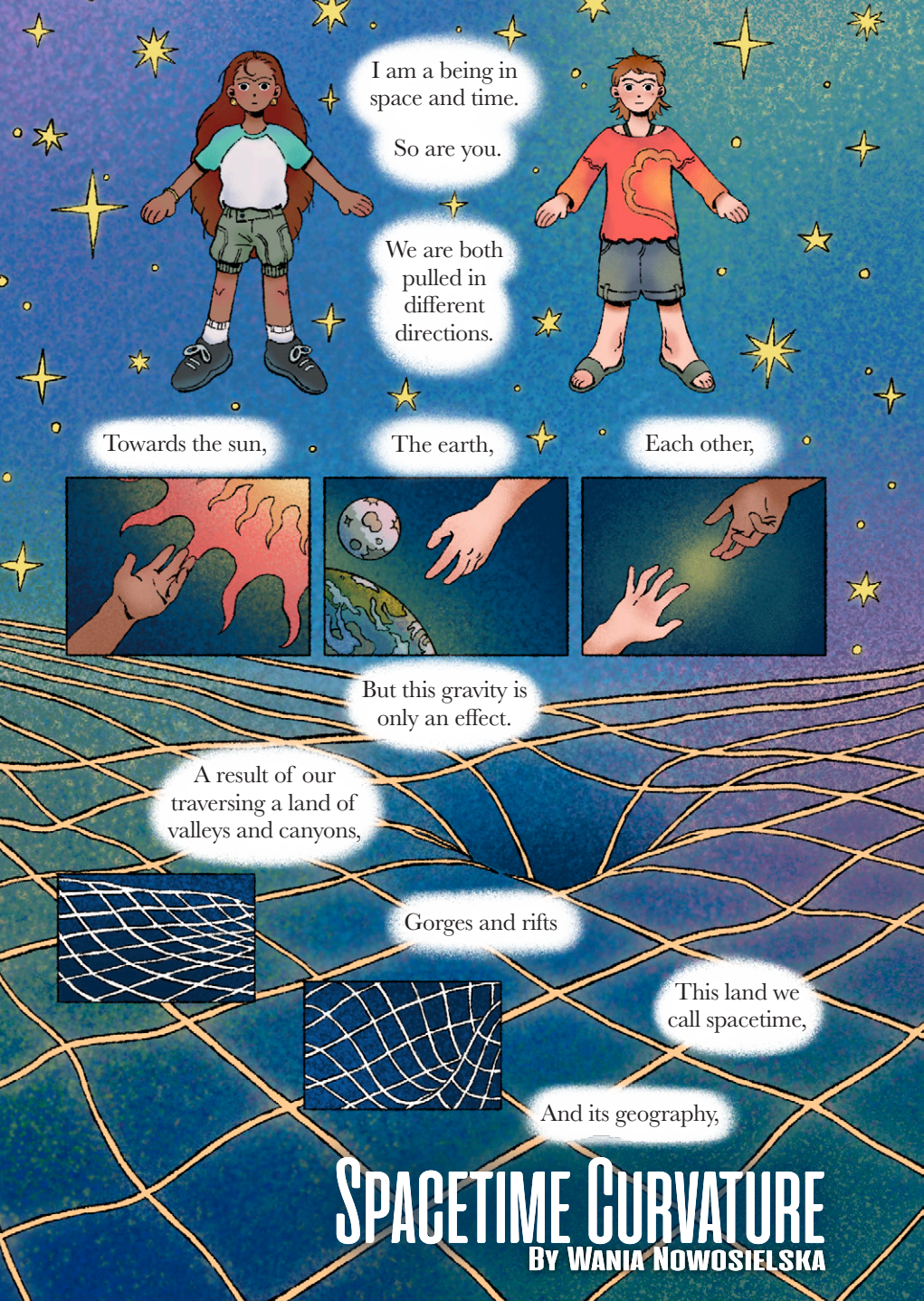
IN SPACE?

COMING UP:

LISA
2035

LISA MISSION.ORG





I am a being in space and time.

So are you.

We are both pulled in different directions.

Towards the sun,



The earth,

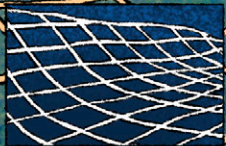


Each other,



But this gravity is only an effect.

A result of our traversing a land of valleys and canyons,



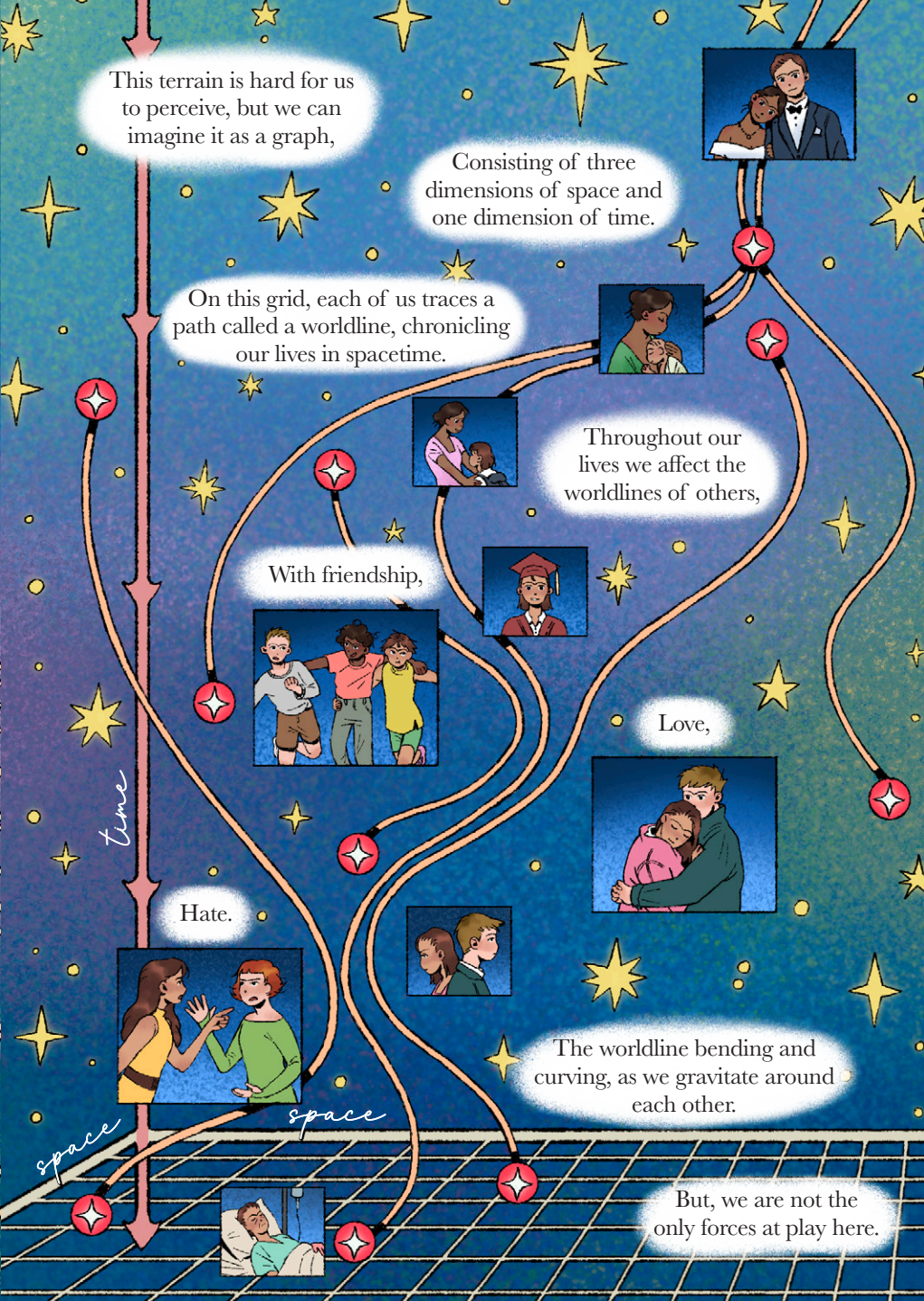
Gorges and rifts



This land we call spacetime,

And its geography,

SPACETIME CURVATURE
BY WANIA NOWOSIELSKA



This terrain is hard for us to perceive, but we can imagine it as a graph,

Consisting of three dimensions of space and one dimension of time.

On this grid, each of us traces a path called a worldline, chronicling our lives in spacetime.



Throughout our lives we affect the worldlines of others,



With friendship,



Hate.



Love,



The worldline bending and curving, as we gravitate around each other.

But, we are not the only forces at play here.

If you place a giant in the grid's four dimensions,

All worldlines will reshape around its mass,

Where space elongates and time slows down.

You might think that you are traveling in a straight line,

All the while being beckoned towards its grip.

And sometimes,

From afar,

You might be able to spot a behemoth among giants,

The black hole.

The black hole creates a gorge around it like no other.

If a traveler, blind to the danger, approaches its horizon,

They will unwittingly become lost to the world they once knew.

Time will serve them differently,

Moving slower and slower.

And if they choose to return while they can,

They will find that life has moved on without them.

Once a traveler ventures far enough,
the black hole's grip is inescapable,



The space around it stretched so thinly,

And the terrain so steep,

That not even light
can disobey its pull.

There is nothing
left to do,

But fall into the
giant's maw.



Artist Biographies



Anna Helminen is a visual storyteller and artist from Finland. Anna thrives when creating using expressive linework, heartfelt storytelling and complex characters. She is drawn towards comics, sequential storytelling and pacing, as well as character design and the use of traditional tools. She also enjoys illustrating children's books, writing out detailed scripts and painting in the more traditional sense of the word. Anna has a BA in Fine Arts from Saimaa University of Applied Sciences. She has illustrated several children's books among other commission work. When Anna is not huddled over drawing supplies and lost in imaginary worlds, she spends her time rock climbing and enjoying nature with her four-legged assistant Neva. Instagram @annahelminen www.annahelminen.com



Giorgina Walther is a versatile Graphic Storyteller, Comic Artist and Writer. She was born in 2001 in Hamburg, Germany. She grew up in Germany before moving to Paris where she attended and finished High School. In 2021 she studied at the School of Visual Arts in New York for one Semester, before moving back to Hamburg in order to study Japanology at the University of Hamburg for one year. Since 2023 she has been studying at the Graphic Storytelling Bachelor program at The Animation Workshop in Viborg. giorginawalther.my.canva.site/portfolio-website Instagram @corricellaa



Leonor Silva is a Graphic storyteller from Lisbon, Portugal. A multimedia artist, passionate about play, colors and characters. Her Mediterranean culture and roots, as well as her infinite love for people, very much shapes her work: it is intuitive and not afraid of experimenting. She is a sun loving artist, who really really likes summer. With a special place for analogue techniques, her art translates into a fun and spontaneous collection of characters and stories. Find her on instagram: @liionor or on her website liionor.my.canva.site



Pelle Ditmer is a Danish comic author, illustrator and easily distracted artist. He is currently studying at The Animation Workshop in Viborg, learning the mystical secrets of storytelling. He is inspired by colorful science fiction, dark fantasy and whatever new shiny thing catches his fleeting attention. At the moment, he is fascinated with the idea of combining 2D and 3D art to create something uniquely visually expressive, whether it be in the medium of comic books, video games or infrequent Instagram postings over @pelleditmer



Freja Hellenden is a Danish illustrator and comic artist based in Aarhus. Her work varies between digital and traditional media, and always strives to bring life, movement and storytelling into every moment. She grew up in Silkeborg, Denmark, surrounded by lakes and forests. She works with stories and art every day for anything from science communication and illustration to video games and animation. Her favorite motifs are people doing things and saying things, birds and fish, trees and flowers, streets and towers. Find her work Instagram: @freja.ytting or frejaytting.myportfolio.com



Wania Nowosielska is a Polish illustrator and comics artist, currently studying Graphic Storytelling at The Animation Workshop. They are passionate about science communication, with a focus on biology and nature. Their other interests include folklore, myths and legends, horror movies, going on walks and playing with their dogs. Find them at wanianowosielska.myportfolio.com/

The Black Hole Comic Project joins scientists from the Niels Bohr Institute and artists from VIA's Graphic Storytelling Program at The Animation Workshop in Viborg to bring black hole science to life as comics.

The collaboration began in Fall 2025 with a series of micro lectures over the following few months to learn about different aspects of black holes and gravitational waves. The students' minds expanded and there were questions galore, deep diving answers, spirited conversations, unspooling of big ideas and concepts, and trying not to be frightened of the math! Students then set off to write and craft mini comics to explain those ideas in a simple way that the public could understand. The collaboration was a real back and forth between everyone involved, and a true learning experience for all.

The result is what you see here. We hope that you enjoy reading and learning about black holes and that it sparks your interest to investigate the topic on your own!

DOWNLOAD THE
COMIC HERE!



Rodrigo Panosso Macedo is currently an Assistant Professor at the Niels Bohr Institute, University of Copenhagen. Originally from Brazil, he has held research positions in Germany, the United Kingdom, Portugal, and Denmark after completing his PhD at the University of São Paulo. Like graphic art, his research on black holes and gravitational waves is fundamentally shaped by geometry. Thanks to the support of the Carlsberg Mindelegat, from which he received the grant for this project, he has been able to merge his long-standing passion for comic books with the fascinating world of spacetime and black hole physics.



Jose M. Ezquiaga is an Associate Professor at the Niels Bohr Institute, where he leads the LIGO group. The LIGO Collaboration is responsible for the discovery, and subsequent detections, of gravitational waves — ripples in space and time produced by extreme gravitational systems in the cosmos such as binary black hole coalescences. Jose's research leverages gravitational-wave observations to drive new discoveries at the intersection of fundamental physics, cosmology, and astrophysics.



Cecil Castellucci is the Eisner nominated, Shuster award winning and New York Times Bestselling author of novels and graphic novels. Titles include, Shade, the Changing Girl, The Plain Janes, Soupy Leaves Home, Shifting Earth, and Odd Duck. Her licensed works have been published at DC Comics, Dark Horse and Oni. In 2023 they were awarded a Fulbright to Denmark where they are a guest lecturer at The Graphic Storytelling Program at TAW in Viborg. They've written librettos for operas which incorporate comics and science. A long time space enthusiast, they volunteer with the NASA Solar System Ambassador Program. They live in Montreal. www.cecilcastellucci.com

Portraits by Mads Ellegård Skovbakke

The Black Hole Comic Book Project is grateful to those that allowed for this collaboration to happen and we'd like to acknowledge:

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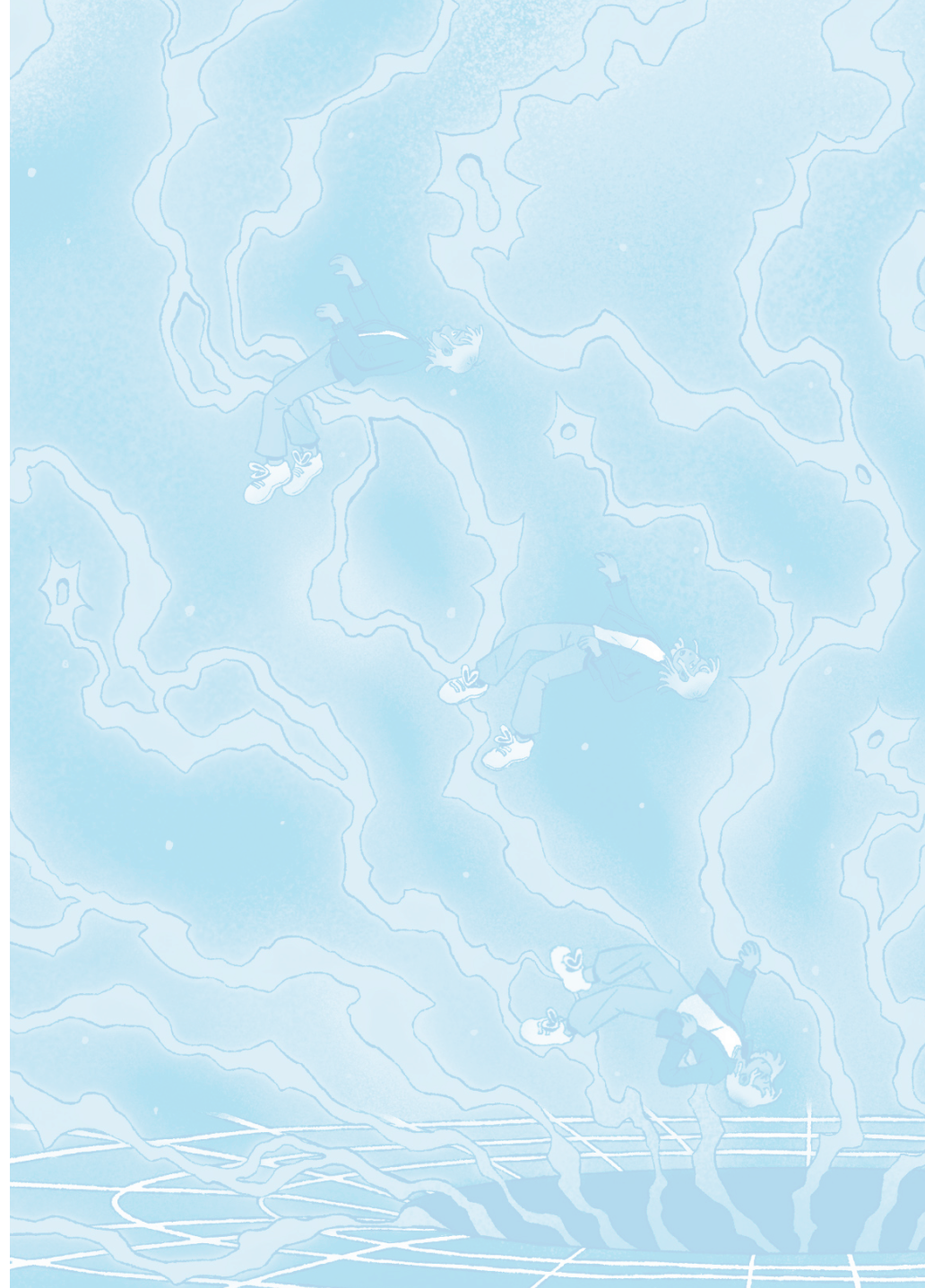
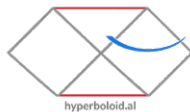
Carlsberg
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The Animation Workshop
VIA University College



VILLUM FONDEN





THE BLACK HOLE COMIC BOOK
PROJECT IS A PUBLIC OUTREACH
COMIC BOOK COLLABORATION
BETWEEN RODRIGO PANOSSO
MACEDO AND JOSÉ MARIA EZQUIAGA,
SCIENTISTS CURRENTLY AT THE
CENTER OF GRAVITY AT THE NIELS
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GRAPHIC STORYTELLING AT THE
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CARLSBERG MINDELEGAT AND IS
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