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Rowina Nathan | OzGrav ECR Workshop
@pinkastrophysicist

How does the height of a pendulum drop affect kinetic energy of cart after collision?

Joseph Darling
Unit 4 Physics

Physics Concepts

A pendulum, when dropped from a known height, will have a certain gravitational potential energy (GPE). The height is measured as the vertical distance from the lowest point of the pendulum to the position at which it is dropped. In theory, all GPE is converted to kinetic energy (Ek) when the pendulum reaches its lowest point, this is called the equilibrium point and the pendulum bob should collide with the cart at this point.

GPE is calculated with the equation:

$$GPE = mg\Delta h$$

and kinetic energy is calculated with equation:

$$E_K = \frac{1}{2}mv^2$$

From these equations we can derive the variables in the investigation. The amount of energy the cart has when it is moving can be calculated given the velocity and the mass. This is proportional to the height of the drop as the amount of energy transferred in the collision will depend on the initial GPE of the pendulum. In the investigation the mass of the cart and the height of the pendulum bob will be altered to find the effect this has on Ek of cart.

An elastic collision is one that all energy is transferred from initial to the final state. In this investigation it will be possible to determine the amount of energy transferred from pendulum bob to cart and hence the proportion of energy transfer or elasticity of collision. Because an airtrack is being used in this method, friction is negligible and should not have an dramatic effect on results. The same can be said about air resistance.

Aim

Investigate the relationship between height of pendulum drop and resulting kinetic energy transferred to cart after a collision. Additionally, explore the relationship between the mass of cart and kinetic energy transferred. Compare the efficiency of this energy transfer for each trial.

Hypothesis

The velocity of the cart is proportional to the square root of the height of the drop. When altering the mass of the cart the same amount of kinetic energy will be transferred to the cart but the velocity of the cart should be different. The elasticity of the collisions should vary slightly. If the drop is higher elasticity will be lower as more energy will be released, as sound and heat, in the initial interaction between cart and pendulum bob. Additionally the point of contact will be less precise or off center leading to less energy transfer.

Methodology

Equipment:

- Camera with tripod
- Airtrack with cart
- 40-50 cm string
- Retort stand with rod
- Sinker, aprox. 50 g
- Protractor
- Level
- Scissors
- Whiteboard marker
- 5 x 25 g masses
- Electronic scales
- Masking tape
- 30 cm Ruler
- Computer
- Tracking software

Height (m)	Drop Angles (± 1°)
0.00	90.0
0.05	55.9
0.10	40.9
0.15	28.9
0.20	18.1
0.25	7.9

TABLE 1 – Drop angles for each height

1. Arrange equipment as seen below in Diagram 1. Measure and record the following parameters: Mass of cart, length of cart mass of sinker and length of pendulum string when set up.

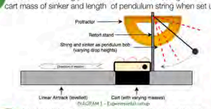


DIAGRAM 1 – Experimental setup

2. Arrange tripod and camera so that at least 1 meter of linear air track with the retort stand is in the frame. Trace around tripod legs with marker in case the tripod is moved. Mark the position of cart on track that will be used in all trials.
3. Turn recording and airtrack on and release the pendulum from 0.05 m. Use Table 1 for angle reference. Repeat this 3 times in quick succession. Turn recording and airtrack off.
4. Repeat Step 3 for remaining heights. To investigate the effect of mass use a similar process. Use a constant height of 0.15 m and weigh each mass before adding it to the cart. Ensure each mass is secure before testing.
5. Upload all videos to computer and use video tracking software to determine the velocity of the cart for each trial after the collision. Record all the data in a spreadsheet for easy calculations.

Risk Management

- Be cautious when cutting string using scissors.
- When airtrack is on dust inhilation could occur. Wear a face mask if necessary.
- Lifting heavy objects. Assistance will be needed when adjusting airtrack.

Discussion of Results

The primary data collected illustrated some trends between the main variables. The relationship found between height of drop and kinetic energy generally agrees with theory and the expected. Calculating the % Energy Transfer, from the proportion of energy transferred from gravitational potential energy to kinetic energy of cart, assisted in explaining some of the findings of the investigation. The error bars provided on Figure 1 were most likely underestimated because other errors that could have affected results were not accounted for in calculations. The experimental methods could definitely be improved in future investigations.

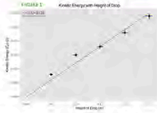


FIGURE 1 – Kinetic Energy over Height of Drop

Examining the % Energy Transfer with Height of Drop (Figure 2) it is obvious that there is a downwards trend. Qualitatively, the energy transfer decreases 3% for every 10 cm increase in height as found from the gradient of the trendline. Note that over the narrow range of 0.2 meters that we tested the relationship was approximately linear. The same can be said about Figure 1. This decrease in energy transfer can be explained by the increase in sound and heat energy released via the collision as the drop gets higher. This relationship can assist in explaining the data points above the trendline in Figure 1 (height of drop (Δh) = 0.03 and Δh = 0.1). The slightly higher kinetic energy can be explained because there is a higher % Energy Transfer in these cases. The trend in Figure 1 (although approximately linear) is more accurately represented by a curved line with a decreasing gradient, the gradient of this trendline at any point is proportional to the % Energy Transfer.

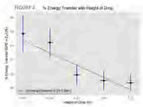


FIGURE 2 – % Energy Transfer with Height of Drop

$$Gradient\ (m) = \frac{\Delta E_k}{\Delta h} \quad \% Energy\ Transfer = \frac{E_k}{mg\Delta h}100$$

$$\therefore m \propto \% Energy\ Transfer \Rightarrow As\ \% Energy\ Transfer \downarrow \ldots m \downarrow$$

The errors accounted for in the investigation were mostly caused by equipment and measurements. Conducting the experiment involved almost constant human interaction leading to unwanted human error which could possibly skew results. When dropping the pendulum by hand it was difficult to determine whether the pendulum bob received extra velocity from the action of the drop. It was also impossible to hit the same position of the cart in every trial. A dropping apparatus would eliminate most of this random error and would lead to more valid results. Additionally, the cart was being held in place by hand simultaneously to the pendulum drop. Similar to the dropping action of the pendulum, it was difficult to release the cart without applying a force on it in some direction and thus affecting the final measurement for the kinetic energy. Again, an apparatus to hold the cart in place while the pendulum is being dropped would be sufficient in eliminating this error. For the investigation to be more successful greater than three trials should be conducted to ensure that random errors do not hinder the validity of results. Five to ten trials for each trial would most likely be effective in reducing these errors. A possible systematic error arose from the use of the scale. When weighing various "25 g" masses the scales returned a weight 25.7-26.7 g suggesting that the scales were not correctly calibrated or were biased in over measuring weight. This issue could have caused the final calculations for Ek to be greater than the actual value.

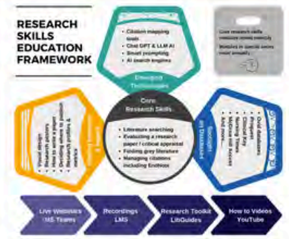
Principled decisions were made in the choice of using a linear air track and measuring the velocity of the cart using video tracking software. An air track, opposed to a cart moving on wheels, eliminated the majority of complicated effects caused by friction which would have decreased the measurement of Ek. Video tracking provides an accurate measurement for velocity with very small tolerances relative to the measurements (±1.81%).

Conclusion

The investigation produced results that support the hypothesis and pro
The designed method did not eradicate all variables affecting the kinet
explained using relevant physics concepts. The data cannot be consi
However, the data collected suggests a clear increase in kinetic energy
Given the data for the second independent variable, a confident con
kinetic energy cannot be reached. These errors leave room for much

Research Skills Education Framework

Alice Anderson - Director, Library Services - Monash Health
BIMS | Dip PWE | GradCertEdStud (DigiLrn) | ALIA CP (Health)



1. Learning context

The educational context is online adult learning at a large, distributed health service in Melbourne, Australia including seven teaching hospitals.

The training is delivered within a workplace setting by health librarians to all health professionals including medical, nursing, midwifery, pharmacy, allied health, and to non-clinical areas such as Quality and Safety.

2. Digital delivery

Online delivery is a change in direction from the past when training was delivered in person, unrecorded, over multiple sessions, at individual campuses. The transition to digital learning was made in response to the pandemic, and it has been a lasting change.

Training modules are delivered via live webinars and captured recordings. The alternate delivery modes support asynchronous and synchronous education which provides different pedagogical opportunities to engage learners, as recommended by Mirriahi & Vigentini (Mirriahi & Vigentini, 2017).

While synchronous webinars offer invaluable interaction between instructors and learners, asynchronous videos provide a secondary, flexible, option. These supplemental videos give learners control over when and where they learn, which has value in health care where there is a paucity of time and education must be designed for maximum convenience.

A shift towards online education in the health sector is not a passing trend. Virtual adaptations of traditional training accelerated during the pandemic, and they have been found to be effective by numerous studies (Hayat et al., 2021, Ribeiro et al., 2020).

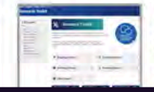
Online education is also suitable in a health care context because learners are often professionals for who distance education is more effective, or at least as effective, as traditional classroom instruction (Siemens, 2015).

The framework scaffolds library training for the key competencies required for research and evidence-based practice in health care. It includes:

- core modules that recur regularly
- special series with less frequent topical modules
- supportive on-demand resources
- convenient digital delivery modes

Training for core competencies is placed at the centre, with special series providing additional learning pathways into specialised areas. The combination of core and special modules provide opportunities for building a wide range of knowledge and skills from foundational to intermediate to advanced.

The framework relies on digital technologies, and it is underpinned by on-demand library resources that support self directed learning.



In particular, modules in the framework align with the library's comprehensive online Research Toolkit, which is shown on the left.

The library runs the framework as an interdisciplinary education program.

3. Education analytics

The use of digital technologies creates opportunities for data informed design through the use of analytics.

Attendance data provides insights for the timing of live events and most popular topics. This information is used to adjust scheduling, improving convenience for busy clinicians.

Data from evaluation forms provides important information about learners' motivations, their experience, and satisfaction.

Chart 1: Drivers for participants

Chart 1 shows the main reasons for attendance at live training events, which indicates needs that must be taken into account when designing training.

Learners are also asked to score their experience. More than 94% of evaluations ranked the training at the maximum 5 star rate.

5.0 ★★★★★

Since the introduction of the Framework, participation in research skills training has soared at Monash Health with the library on track to train more than 2,000 people in 2024. At the same time, the number of live events has lessened which indicates more effective and efficient use of library staffing time, as shown in chart 2.

Utilisation of supportive on-demand resources including the online Research Toolkit and videos have risen in tandem with framework development.

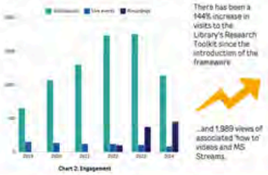


Chart 2: Engagement

There has been a 944% increase in visits to the Library's Research Toolkit since the introduction of the framework.

...and 1,989 views of associated 'how to' videos and MS Streams.

4. Iterative development

The framework was developed iteratively, driven by input from participants. Feedback is continually sought from learners to provide data that informs constant re-evaluations and improvements.

This approach is described by Thakur as "accelerated prototyping with iterative feedback". It involves engaging with health care professionals to create a continuous conversation and ensure solutions are driven by end users (Thakur, et al, 2021).

Learners are asked:

- Why they attended the training
- About the learning experience
- If the content was relevant
- For suggestions and comments

Selected comments appear on the right.

> "Thanks so much for all the information/education. It's really useful and beneficial! We couldn't do our research without you."
>
> "It was great to go through different types of finding information and also evaluate the second literature."

5. Where to from here

The library will continue to optimise the framework by:

- Introducing certification for learners that complete core modules and a portion of special series modules.
- Expanding core modules to include education on study designs and systematic reviews.
- Adding a fourth special series on research data management (RDM)
- Increasing integration with disciplinary programs.

References

Hayat, A.A., Keshavarzi, M.H., Zare, S., Wang, W., Feng, X. and Zhang, X. (2021). Investigating the effectiveness of virtual teaching on medical students' learning outcomes during the COVID-19 pandemic: A structural equation modeling approach. *BMC Medical Education*, 21(1). doi:https://doi.org/10.1186/s12909-021-02965-1.

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Thakur, A., Soderlund, T., Kaewkitipong, L., Ractham, P., Eschenbrenner, B. and Fui-Hoon Nah, F. (2021). Digital Technology Fluency for Complex Conditions: Insights from Emergency Room Visits. *Journal of the Association for Information Science and Technology*, 72(7), pp.905–919. doi:https://doi.org/10.1002/asi.24454.

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Keren Moskal - Clinical Librarian & Education Lead - Monash Health

Monash Health

Not all posters are created equal

Scientific Poster Template

Title (40 point type): informative, short, mention of the study de

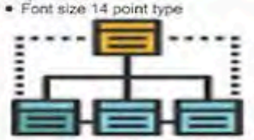
Add author names and information: the list and sequence of authors remains unchanged fr
Include university or department names if needed (24 point type): the superscript number den

Introduction

- Introduction should be 1-3 bullet points on relevant background information & rationale
- Font size 14 point type

Objectives

- Bulleted list of 2-3 research questions
- Font size 14 point type



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Methods

- Basic information about:
  - Study design and duration
  - Inclusion and exclusion criteria
  - Drug regimens
  - Sample size
  - Patient population
  - Statistical methodology
  - Primary & secondary variables
  - Tolerability measures
  - NCT number, if applicable
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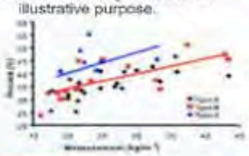

Results

- Patient numbers (flow chart)
- Patient demographics (table)
- Findings presented in the form of table/figures
- Highlights of key findings; bulleted text relating findings back to initial aim and hypothesis
- Table
  - Place it shortly after textual reference
  - Columns and rows should be evenly spaced
  - Foot notes to the symbols used should appear below table body
- Font size 14 point type

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Conclusions

- Summary of findings (2-3 sentences in plain English)
- Implications for research
- Directions for future research
- Study strengths and limitations
- Font size 20 point type

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References

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Disclosures

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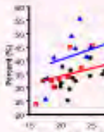
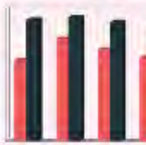
Introduction

Methodology



Results



Conclusions

Scientific Sponsors

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LVK Meeting, March 2023, Northwestern University

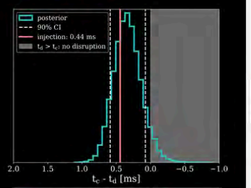
NSBH TIDAL DISRUPTIONS: the best way to measure equation of state?

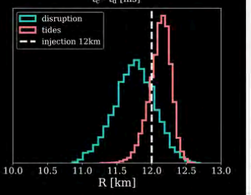
Teagan Clarke, Paul Lasky and Eric Thrane

INTRO

Some NSBH may undergo tidal disruption. Measuring the moment of disruption can provide information about the neutron star equation of state. We simulate this with an optimised system measured in Cosmic Explorer.

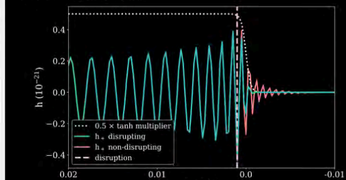
RESULTS





MODEL

BNS waveform x Tanh = phenomenological NSBH waveform



SUMMARY

- We can accurately measure the moment of tidal disruption in gravitational waves with Cosmic Explorer.
- However we gain more information about EOS from tides than from disruption time
- This can provide a consistency check between disruption and tides
- Hints of new physics? phase transitions in neutron stars?
- We still love NSBH for binary stellar evolution physics.

CHECK OUT OUR PAPER! arXiv:2302.09711

MONASH University OzGrav ARC Centre of Excellence for Gravitational Wave Discovery LIGO VIRGO KAGRA

STARS THAT EXPLODE–

HOW MUCH MASS DOES IT TAKE TO MAKE A SUPERNOVA IN THE MOST CHEMICALLY ENRICHED REGIONS OF THE UNIVERSE?

Giulia C. Cinquegrana[1,2*] Meridith Joyce[3,4,5] and Amanda I. Karakas[1,2]

* giulia.cinquegrana1@monash.edu | https://www.giuliacinquegrana.com/

THE QUESTION

Let's take two stars: both have 9M ⊙ but one star ends its evolution as a white dwarf...the other a supernova.

What's the difference between the two? Their chemical composition. A model with one third of the metal enrichment (or **metallicity**) of the sun, 1/3 Z ⊙ , will experience a *hotter* and *more luminous* main sequence lifetime than a model with twice the solar metallicity, 2 Z ⊙ .

The result? The **metal-poor** model grows a **more massive core** which leads to a supernova. The **metal-rich** model cannot grow a core large enough and so will end up a white dwarf.

What about for stars with Z > 2 Z ⊙ ? Do they need even *greater* initial masses to explode? That is the question we set out to investigate.

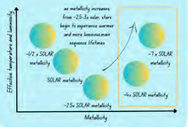
We evolved a grid of 1D stellar evolution models to study the final fate of stars with more than twice the chemical enrichment of the sun.

MESA *Modules for experiments in stellar astrophysics (version r23.05.1)*

Our models cover the metallicity range 1/3 to 72 Z⊙ Z⊙ 0.0025

WHAT DID WE FIND?

While stars with 2 Z ⊙ are cooler and less luminous than those with 2 Z ⊙ *...further* **metal enrichment** causes the opposite.



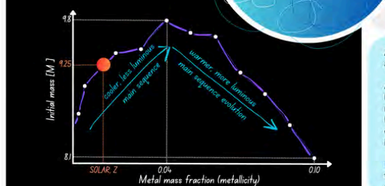
This mass boundary is used to calculate **star formation rates**, **core collapse supernovae rates** and **galactic chemical evolution** models.

WHY DOES THIS HAPPEN?

As the metal content of a gas increases, the opacity and mean molecular weight **both increase.**

An **increasing opacity** leads to a **decrease** in luminosity and effective temperature. An **increasing mean molecular weight** leads to an **increase** in luminosity and effective temperature. The competition between the impact of the two variables is nuanced.

For the most enriched stars-we find that the effect of the higher mean molecular weight dominates, with respect to the growth of the core mass.



The initial mass required for a type II core collapse supernova **does not monotonically increase with metallicity**

Cinquegrana, Joyce & Karakas (2022, ApJ) *Bridging the Gap between Intermediate and Massive Stars I.*

Cinquegrana, Joyce & Karakas (MNRAS, submitted) *Bridging the Gap between Intermediate and Massive Stars. II.*

google scholar page

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2 - Australian Research Council Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D)
3 - Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
4 - CSFK, MTA Centre of Excellence, Budapest, Hungary
5 - Lasker Fellow, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

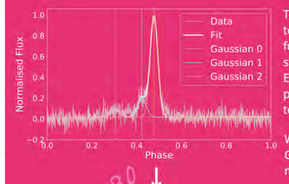
MONASH University ASTRO 3D

Pulsar timing with dynamic pulse fitting

MONASH University

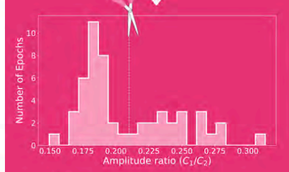
We introduce a dynamic pulsar timing method that allows for pulse shape variation. Not only does this method improve pulsar timing sensitivty, it also characterises pulse shape.

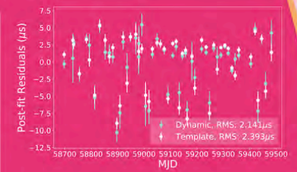
Kookaburra Code

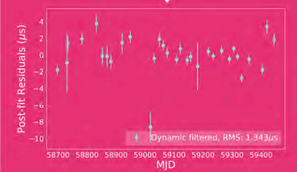


Traditional timing uses a template that is unable to vary with pulse shape. We fit a sum of basis functions to each observing epoch using nested sampling implemented in our **Kookaburra** code. Each fit is independent. This work uses data from pulsar J1103-5403 taken with the MeerKAT telescope. We fit 3 Gaussians.

We see clustering in the amplitude of the second Gaussian, use this to make a cut and move to single mode timing.







Summary

Our timing method performs similarly to traditional methods when all pulses are included.

We can use the shape characterisation to time a single mode.

This greatly improves the timing sensitivity - by a factor 1.7.

Dynamic fitting characterises the shape of each epoch, quantifying sub-pulse drifting, nulling, mode changing and shape evolution.

This may offer insight into the pulse emission mechanism!

A factor 3.2 increase in sensitivity to the nanohertz gravitational wave background*

*from this pulsar

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Paul Lasky, Eric Thrane, Greg Ashton
Matthew Miles, Daniel Reardon, Ryan Shannon

OzGrav

NUMERICAL RELATIVITY WITH PARTICLES

PHANTOM NUMERICAL RELATIVITY

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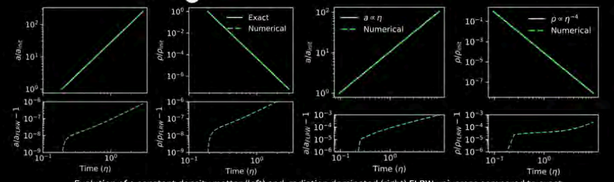
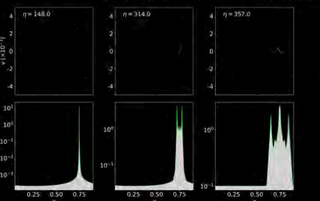
We present a relativistic N-Body / Lagrangian hydrodynamics code for cosmology and compact object mergers. We couple the General Relativistic Smoothed Particle Hydrodynamics Code (SPH) code *Phantom* [1,2], to the numerical relativity framework *Einstein Toolkit* [3]. Initial conditions are provided via *flrwsolver* [4]. We present results on applications to homogeneous and inhomogeneous cosmologies for matter and radiation dominated universes.

einstein toolkit — Metric Evolution — $G_{\mu\nu} = \kappa T_{\mu\nu}$ — Hydrodynamic Evolution — PHANTOM

$g^{n}_{\mu\nu}$ → Interpolate from Grid to Particles → Evolve Particles: Calculate Stress Energy Tensor → $T^{Particles}_{\mu\nu}$ → Kernel Interpolation to Grid → $T^{Grid}_{\mu\nu}$ → Evolve the metric → $g^{n+1}_{\mu\nu}$



Evolution of a constant density matter (left) and radiation dominated (right) FLRW universes compared to exact solutions. We evolve our method until the simulation volume has increased by a factor of 3 billion.



The evolution of a colisionless fluid with non-linear perturbations to the FLRW metric. Our method allows for gravitational collapse without any special treatment.

- We performed simulations of matter and radiation dominated universes with numerical relativity + particles
- Shell crossing can occur without singularities or special treatment
- Halo formation is possible!
- Large scale cosmological simulations investigating non-linear effects planned

[1] Price et al. (2018) PASA
[2] Liptai & Price (2019) MNRAS
[3] Loffer et al. (2012) Classical and Quantum Gravity
[4] Macpherson et al. (2017) PRD

MONASH University OzGrav ARC Centre of Excellence for Gravitational Wave Discovery

WHAT IS OUR AIM WHEN WE PRESENT POSTERS?

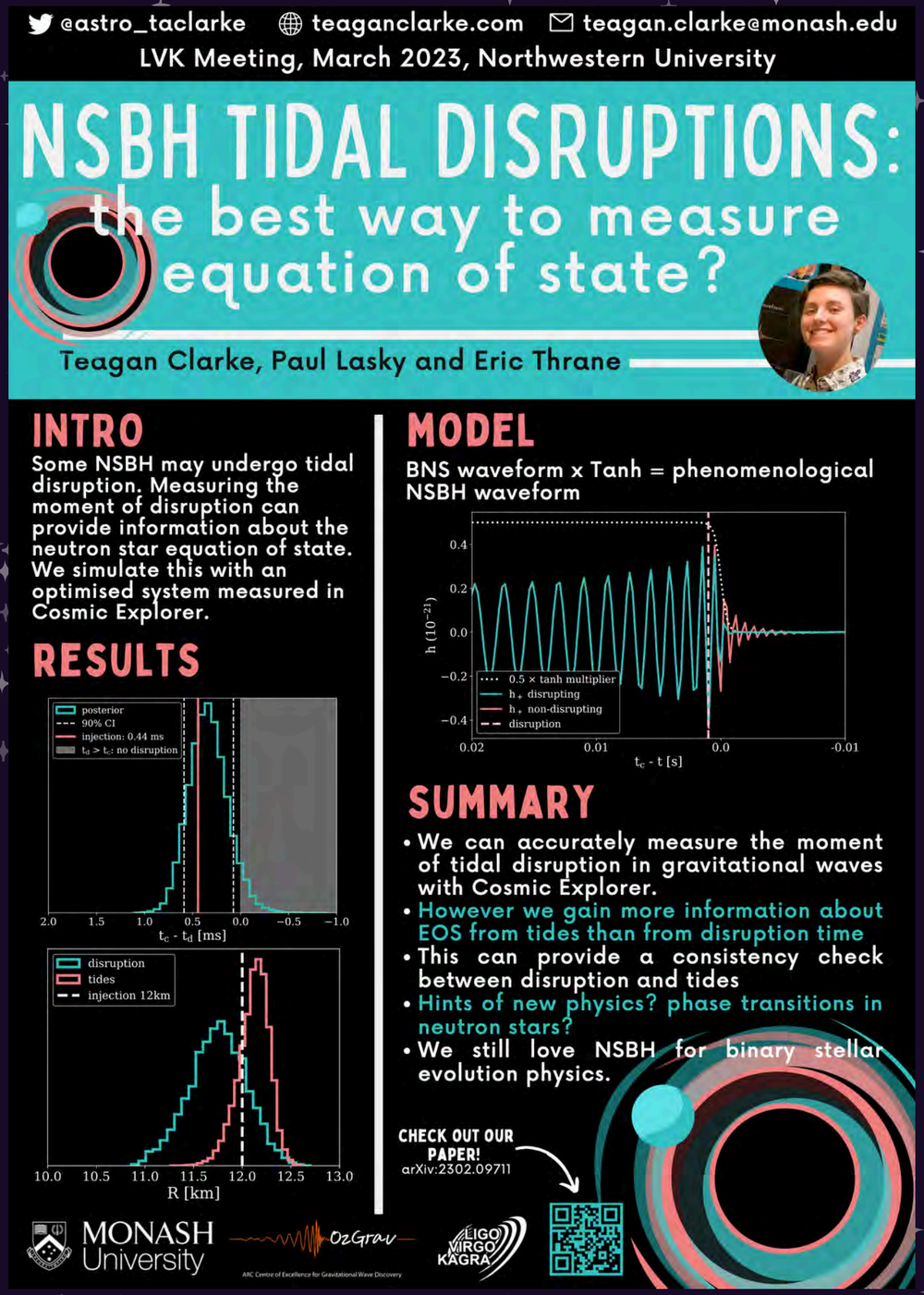
Inform collegues about our research

Find collaborators

GET A JOB

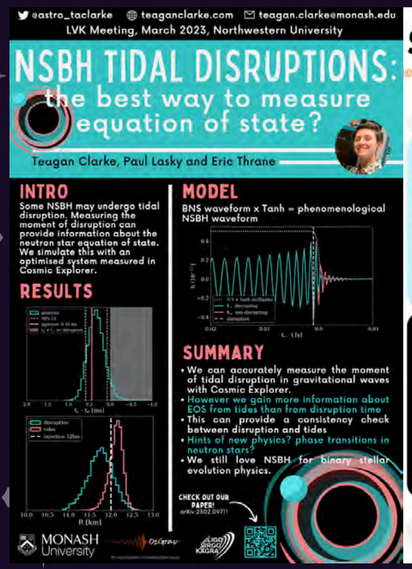
Conferences often have 100s of posters, academics are time poor...

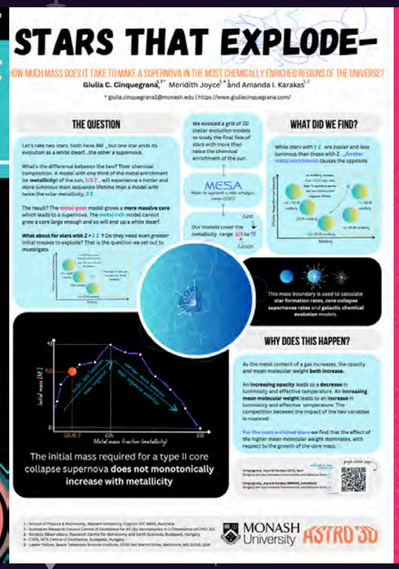
YOU NEED TO STAND OUT

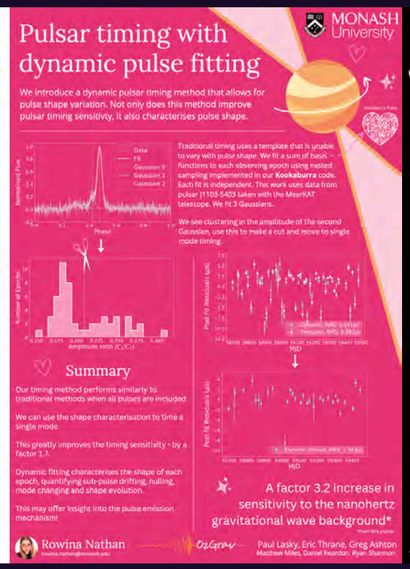


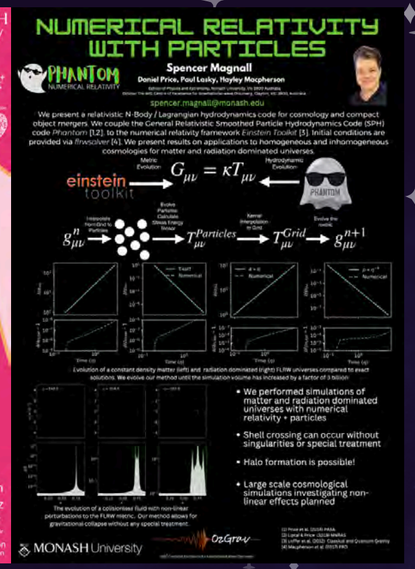
Therefore our posters should be

Eye-catching	→	Colorful, Title can be read at a distance
Easy to read	→	Minimal text
Interesting	→	Images, diagrams, plots
Informative	→	Key take-away message
An ad for you!	→	Picture, contacts



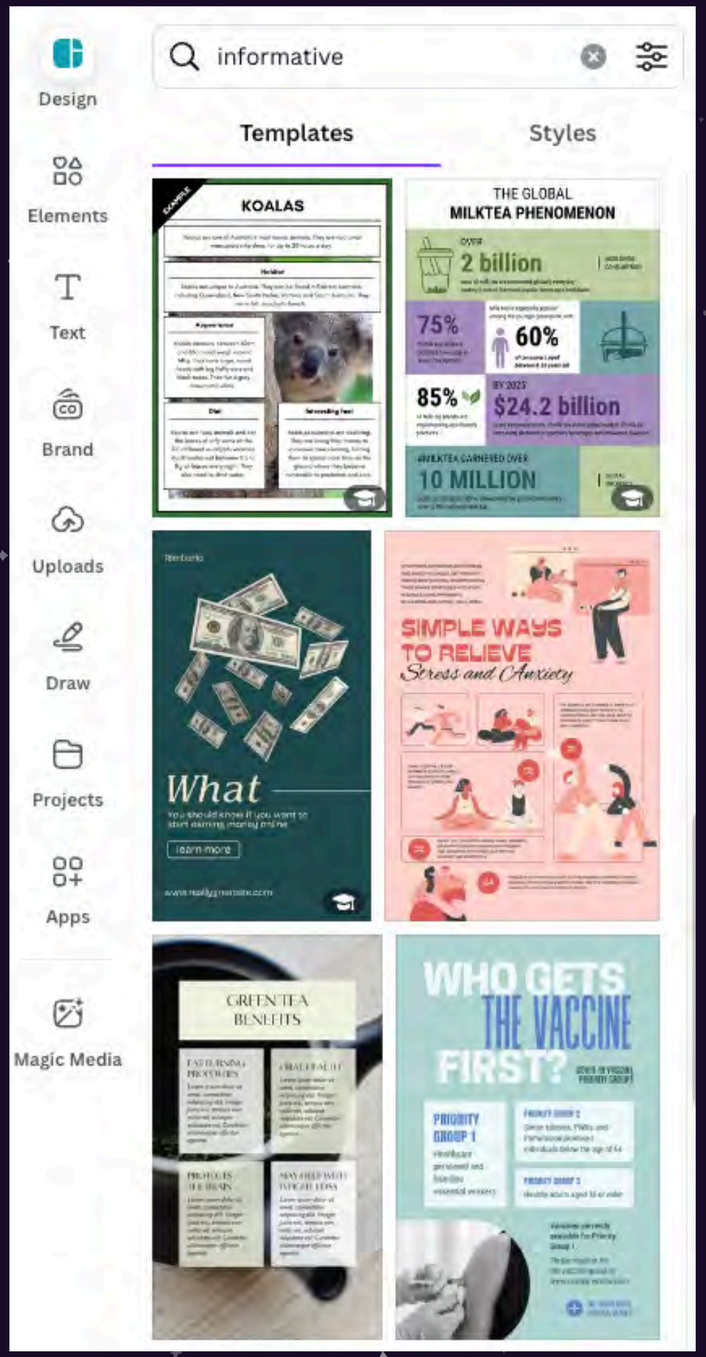






ALL OF THESE BEAUTIFUL POSTERS WERE MADE USING

Canva



WHY DO I RECCOMEND CANVA?

Free

Easy to use

Desktop app

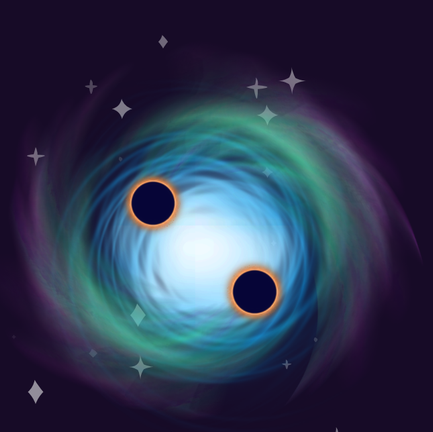
Beautiful graphics

Suggestions

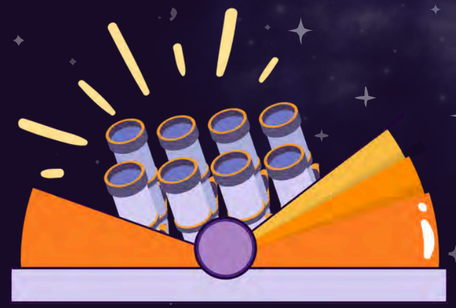
Templates

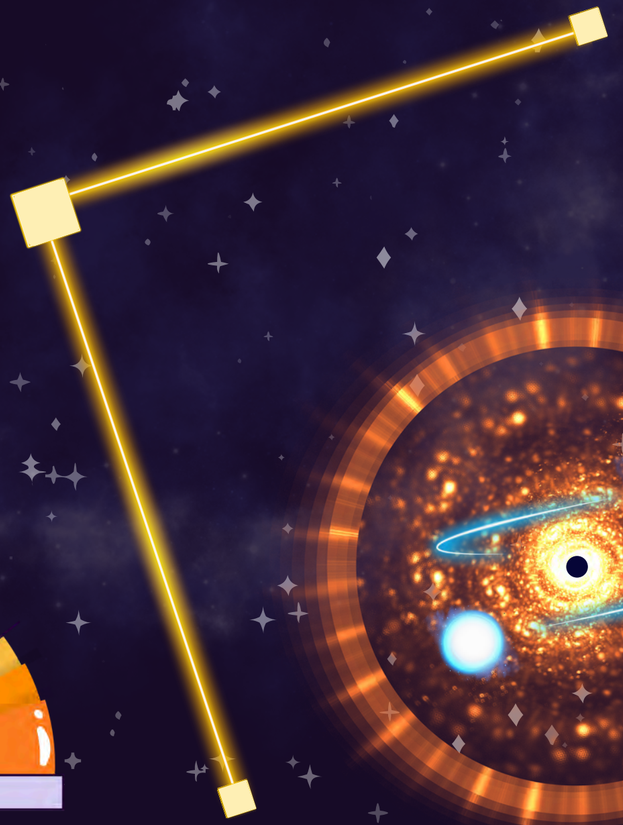
MAKE A MOTIF FOR YOUR SCIENCE

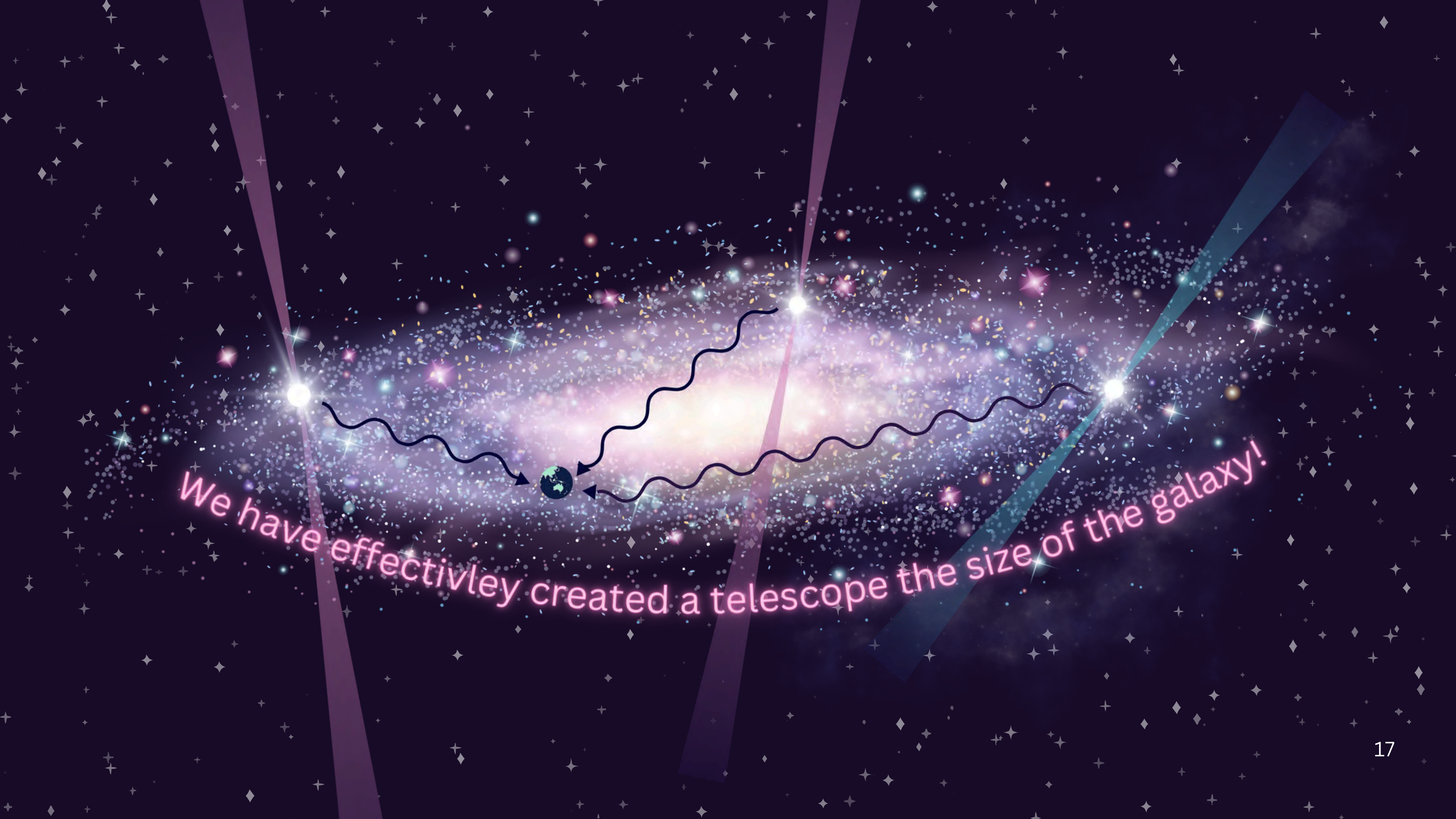
Mine



Yours?






We have effectivley created a telescope the size of the galaxy!

ROWINA'S TIP TOP TOP TIPS

- Create a **colour scheme** before you start
- Use your **motifs**
- Use **SVG graphics** that allow you to customise the colours
- Add a **QR code**
- Include a picture of **you**!
- Use the resources we have (ozgrav gallery)
- Make **matplotlib plots** with your custom colours and save them with a transparent background

ROWINA'S TIP TOP TOP TIPS

- Use as few words as possible
- Save all your favourite logos and graphics in a folder for easy access
- Think about your **audience**, what will stand out
- ALWAYS GIVE IMAGE CREDIT
- REMEMBER THE SCIENCE COMES FIRST - pretty is fun but once your poster is finished step back and ensure it conveys your message.

CANVA

Download the desktop app
https://www.canva.com/en_au/help/canva-desktop-app/

Make your poster the correct size from the beginning (resizing is only available on Canva premium)
A0 - 841 x 1189 mm
A1 - 594 x 841 mm

Download your poster as a PDF for printing

THE DETAILS

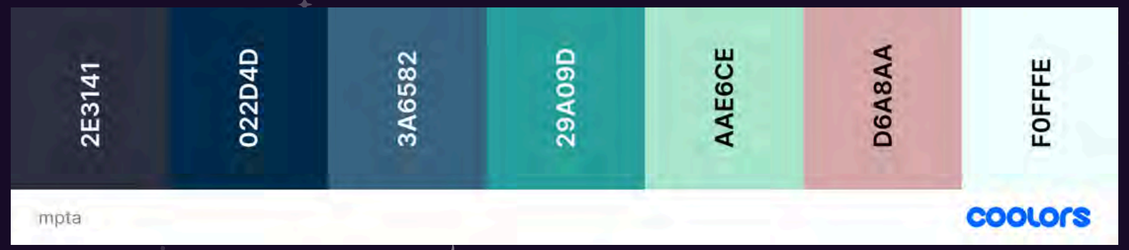
Colour Schemes

I like to use either **coolors** or **Adobe Color**.

coolors is good when you have no idea where to start
https://coolors.co

Adobe Color is good when you already have an inspo image, it can extract a colour scheme from an image.
https://color.adobe.com/create/image

Save your colour scheme as a list of hex codes for easy use across apps



Logos

Save OzGrav logos from the portal

OzGrav
ARC CENTRE OF EXCELLENCE FOR GRAVITATIONAL WAVE DISCOVERY

Save some high resolution university logos in multiple colours

MONASH University MONASH University MONASH University

Use a website like https://www.flaticon.com/ to find matching logos/icons for contact details and other things

THE DETAILS

QR codes

I have emphasised that less is more when it comes to text on posters - this is the place for the details!

Add a link to your paper, your website, or even to open a slack message to yourself. You could do all 3! Remember your poster is an ad for **you**, along with your research.

I use **QRcode chimp**. You can customise the appearance of your QR codes, including the colours!
https://www.qrcodechimp.com

Slack link

Encourage people to reach out to you! Go to the **conference workspace, right click on yourself, go to copy -> copy link**

When people scan your QR code it will start a conversation with you on slack

Chat with me!

linktree

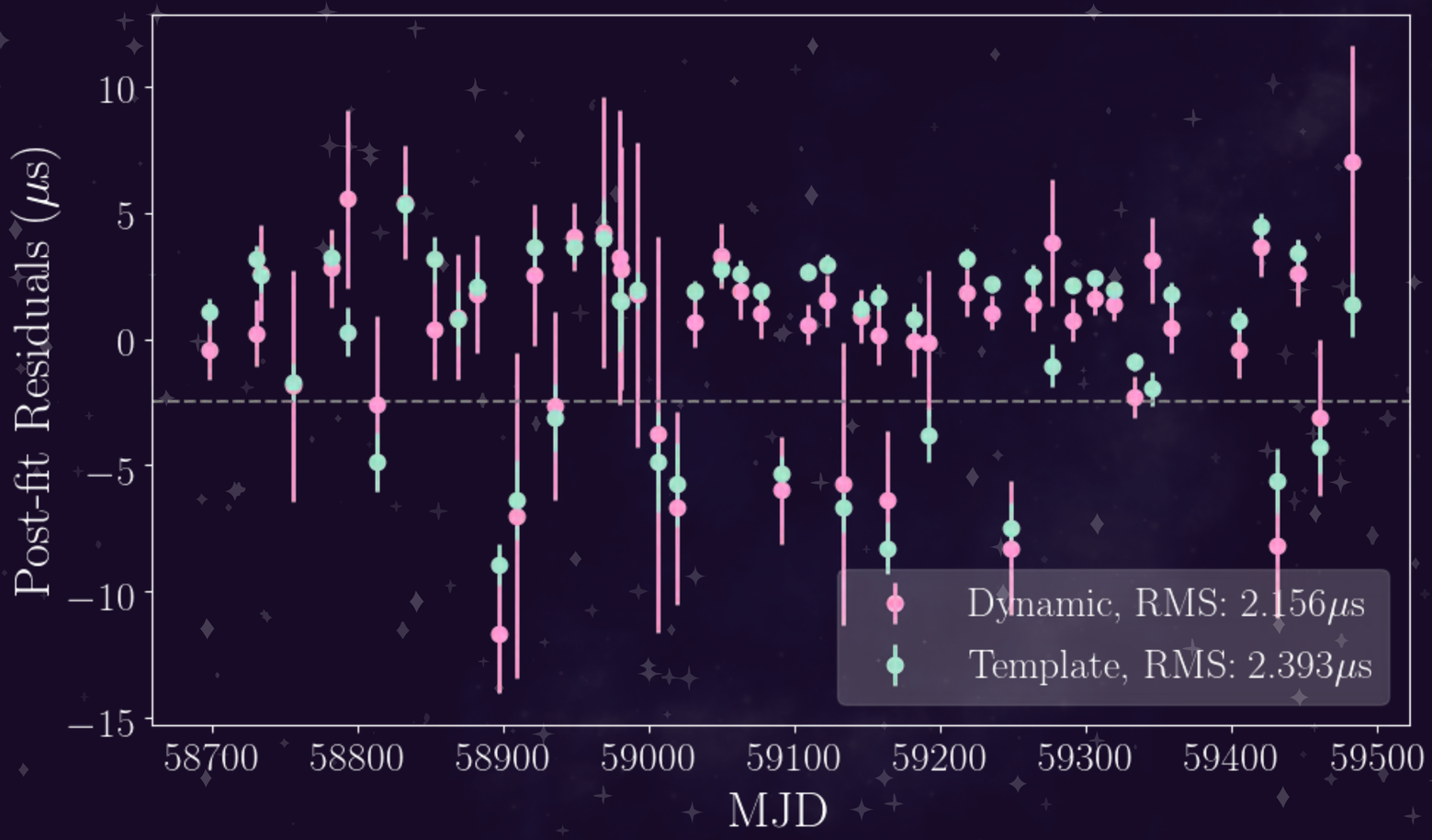
Want your QR code to contain multiple links? Create a linktree! You can make a QR code that opens a page of links. Include papers, your website, your github and a slack link! The options are endless.
https://linktr.ee
https://linktr.ee/pinkastrophysicist

THE DETAILS

matplotlib

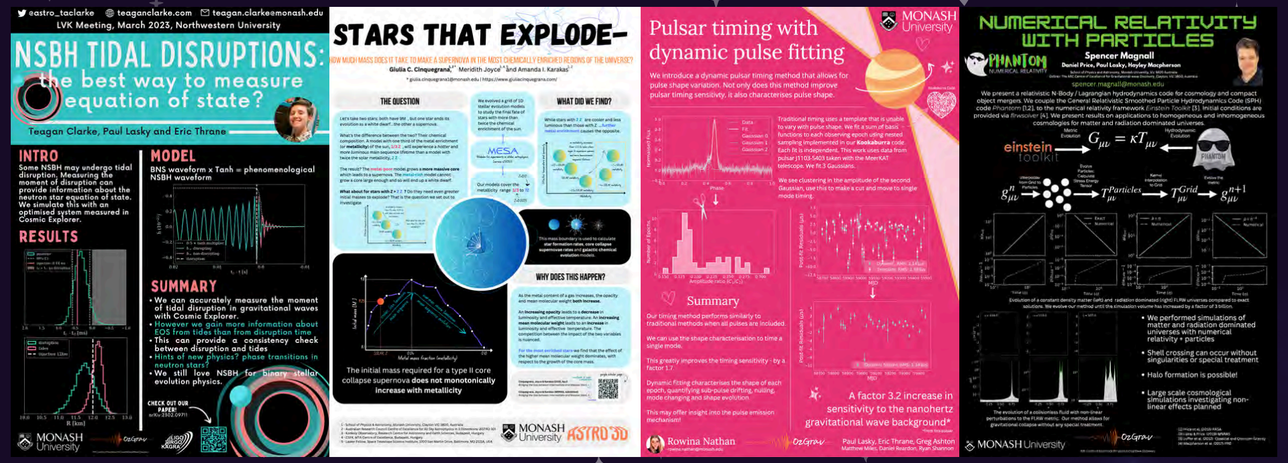
Use plt.rcParams to customise just about anything!

```
plt.rcParams['font.family'] = "serif"
plt.rcParams['font.sans-serif'] = "Times"

plt.rcParams['text.usetex']= False
plt.rcParams['xtick.labelsize'] = 10.0
plt.rcParams['ytick.labelsize'] = 10.0

plt.rcParams['savefig.transparent'] = True
plt.rcParams['axes.facecolor'] = 'white'
plt.rcParams['axes.edgecolor'] = 'white'
plt.rcParams['axes.labelcolor'] = 'white'
plt.rcParams["text.color"] = 'white'
plt.rcParams['xtick.color'] = 'white'
plt.rcParams['ytick.color'] = 'white'
plt.rcParams['axes.labelsize'] = 20.0
```



Then just customise the lines or objects in your plots in the plotting code

```
colours=['#ED7D31','#5B9BD5','#F9C002','#ED7D31','#5B9BD5','#F9C002','#629460']
plt.scatter(pulsar_data['P']*0.001,np.abs(pulsar_data['PDOT']), color=colours[1])
plt.scatter(J1103_data['P']*0.001,np.abs(J1103_data['PDOT']), color=colours[0])
```



Making beautiful posters is easy with Canva (not sponsored I swear)

The less text the better - use figures, diagrams and QR codes instead

Use bright colours and large titles

Remember your poster is an ad for YOU as well as your science