



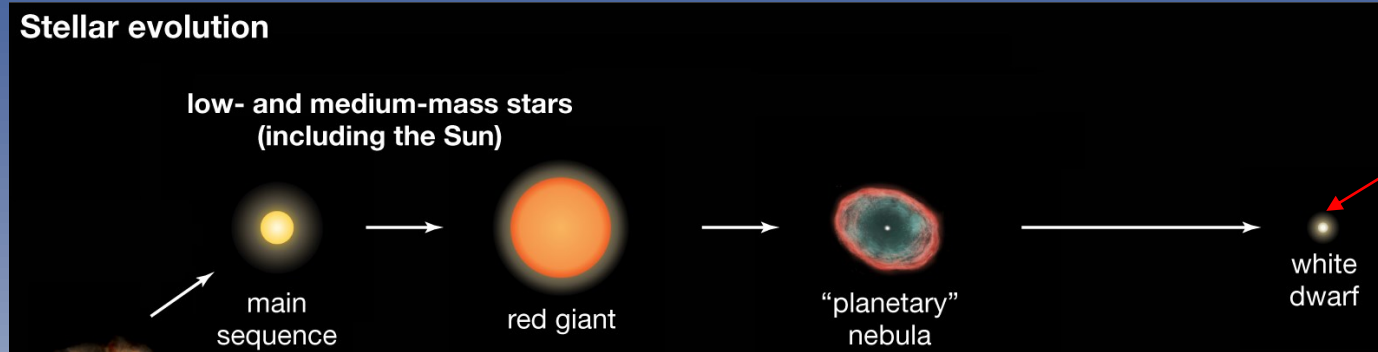
# Delayed Detonation Thermonuclear Supernovae with An Extended Dark Matter Component

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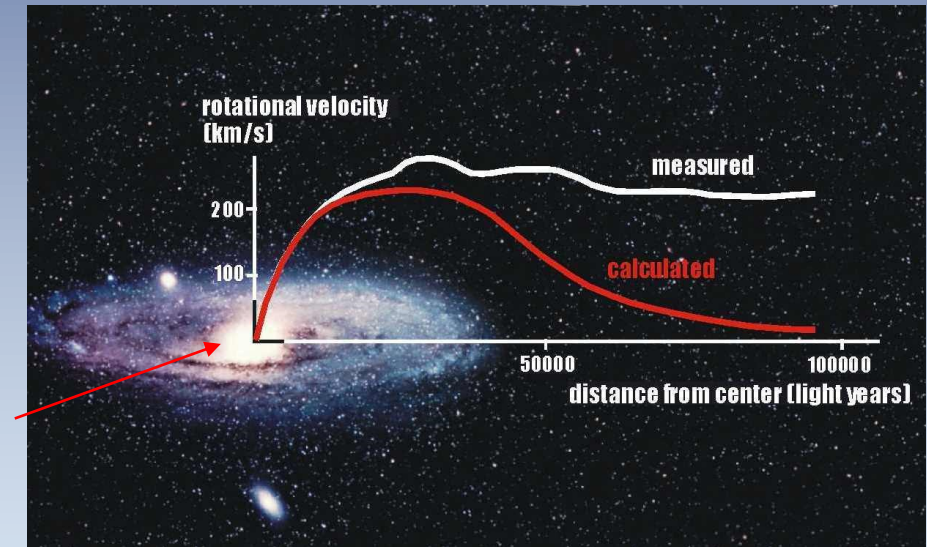
# Dark Matter And Stellar Evolution Path



<https://www.britannica.com/science/star-astronomy/Star-formation-and-evolution>

- Dark matter (DM) ambient density maybe large
- DM collapse together with the molecular cloud
- Stars evolved with a DM core to become WDs

- Low mass stars end up as WDs
- WDs may evolve as supernovae



<https://phys.org/news/2011-12-dark.html>

What would DM admixture do to WDs and Type Ia Supernovae (SNe Ia)?

Numerical Simulations In 1D

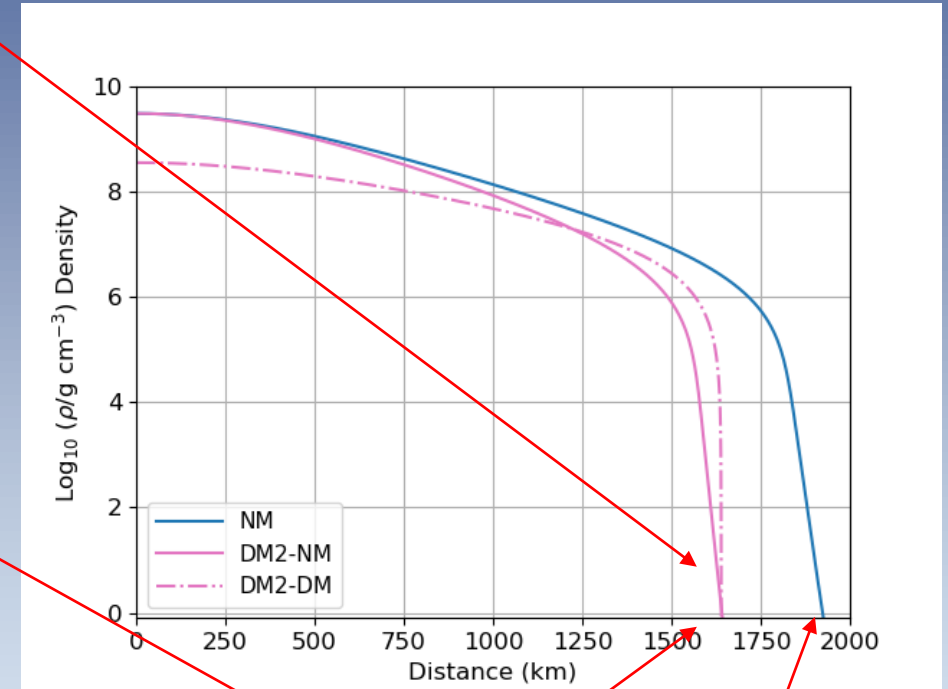
# Progenitors - Dark Matter Admixed White Dwarfs

- Light DM particle mass  $\sim 0.1$  GeV
- DM **is extended and comparable** to the NM

Model	NM	DM-1	DM0	DM1	DM2	DM3
NM $\rho_c$ ( $10^9$ g cm $^{-3}$ )	3.0	3.0	3.0	3.0	3.0	3.0
DM Mass ( $M_\odot$ )	-	0.067	0.120	0.201	0.322	0.494
NM Mass ( $M_\odot$ )	1.374	1.242	1.183	1.124	1.067	1.015
DM Radius (km)	-	975	1160	1380	1640	1920
NM Radius (km)	1930	1890	1830	1740	1650	1560

Stellar Parameters For Supernova Progenitors

## Density Profiles



NM Mass And  
Radius Reduced

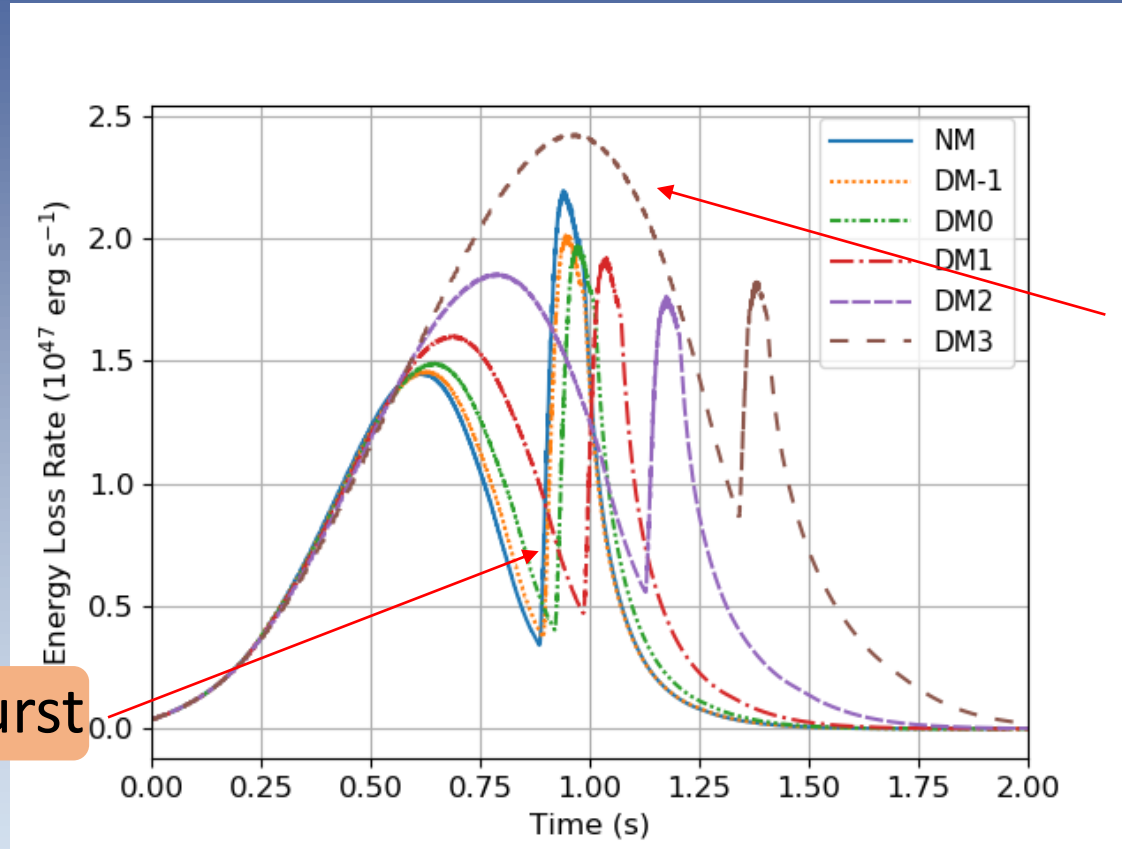
- They are used as progenitors for simulating DM-SNela
- Chan+ arXiv:2012.06857, Accepted By ApJ

# Supernova Neutrinos

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Packages provided by  
<http://cococubed.com/>



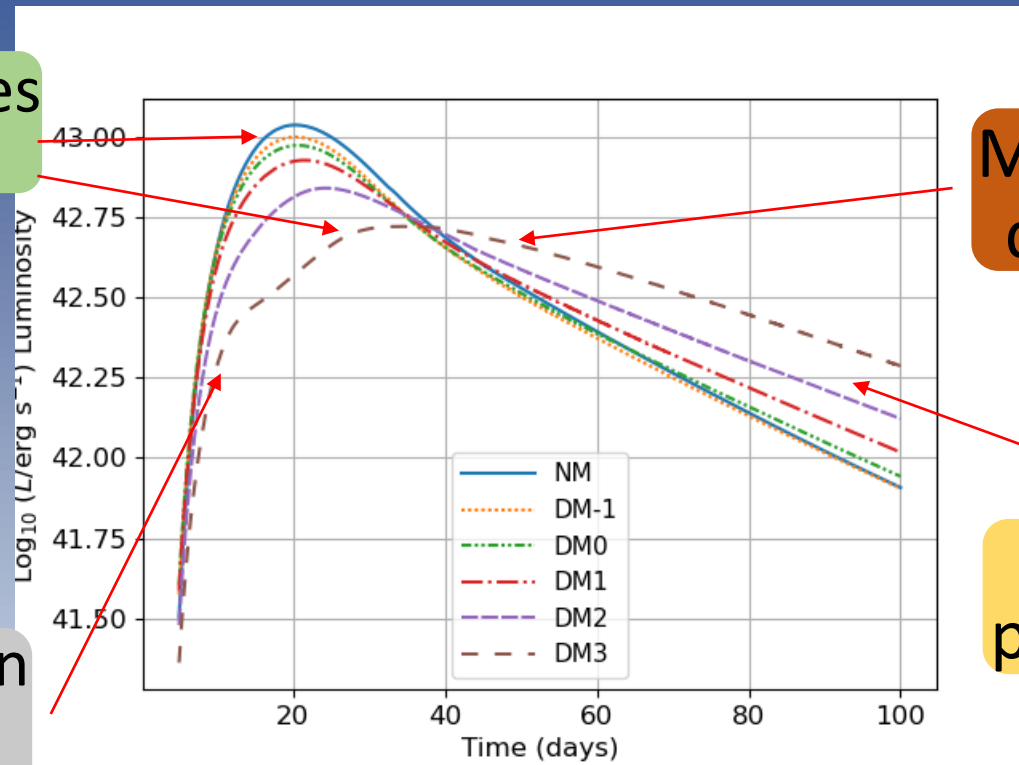
More DM Results In More  
Neutrino Production

Neutrino Burst

- More neutrino produced for more DM admixtures
- Weaker neutrino burst – But overall, more  $\nu$  production

# Supernova Light Curves

Peak magnitudes  
are similar



More DM then  
decay slower

Brighter at  
post-maximum

More DM then  
rise slower

**Dimmer and broader** light curves!

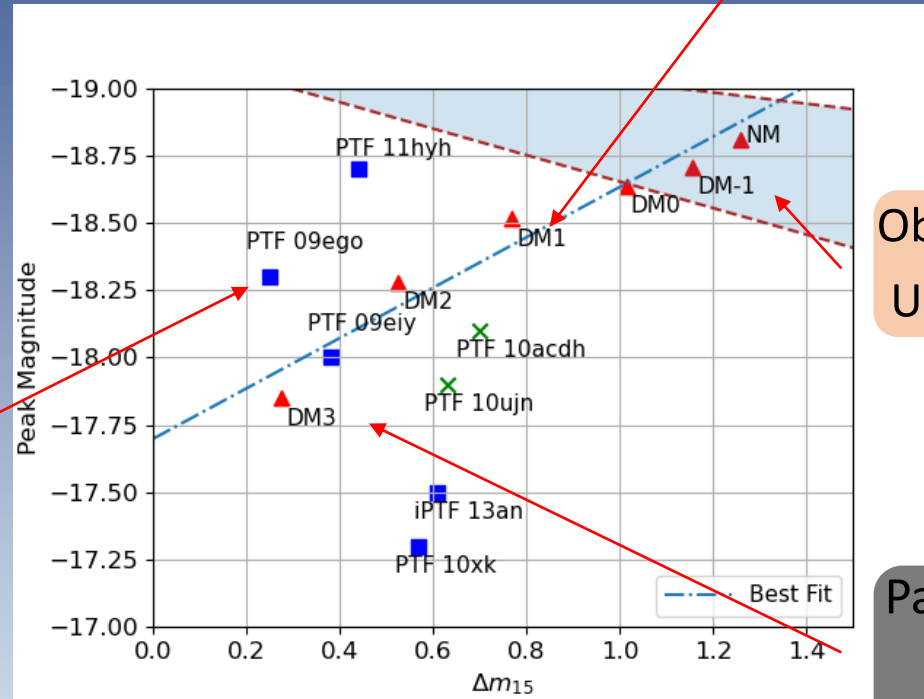
- DM-admixed SNeIas produce unusual light curves
- They correspond to peculiar supernovae – **Examples?**

Computed by  
the SNEC code

# Observed Light Curves

- Interested in the **Peak Magnitudes vs  $\Delta m_{15}$**

Orthogonal trend to the Phillips relation



Observed data through PTF

Observed R-Band usual Phillips relation  
Used as standard candle in cosmology

Parameter spaces unreachable by varying progenitors or explosive mechanisms

- Peculiar supernovae have been observed
- Broad and dim light curves**
- DM models also produce dim and broad light curves!
- Help **provide alternative explanations to peculiar events**

# Summary

- We simulated one-dimensional DM-admixed SNe Ia
- DM is extended and have comparable sizes and masses to the NM
- DM-SNe Ia has a weaker neutrino burst but generates more neutrinos
- DM-SNe Ia produces broader and dimmer light curves
- Some peculiar supernovae could be explained by having a DM admixture

Thank You!

Welcome to contact  
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# Appendix



# The Delayed Detonation Model

- SNela – Explosion of a WD (standard candle in cosmology)
- Explosive modes classified as deflagrations or detonations



<https://www.xpproducts.com/blog/what-is-deflagration-venting>

## Deflagration



<https://www.sutori.com/story/kaho-olawe--3kMhS5YL1RKWWLY7gNX74Ph5>

## Detonation

- Sub-sonic heat conduction
- Super-sonic compression wave
- The **d**elayed **d**etonation (DDT) model is an explosion model of SNela
- A Detonation is generated after the passage of a deflagration

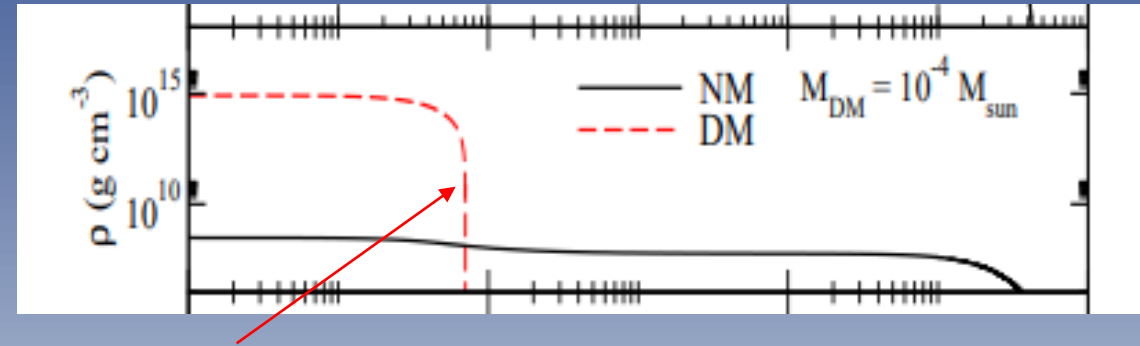
We study one-dimensional DM-SNela using the DDT model

# Dark Matter Admixed White Dwarfs

- Assumed ideal degenerate Fermi gas for DM

Density Profiles

$$\frac{dp_i}{dr} = -\frac{G(m_1 + m_2)\rho_i}{r^2},$$
$$\frac{dm_i}{dr} = 4\pi r^2 \rho_i.$$



Compact DM

- The index  $i = 1(\text{DM})$  and  $2(\text{NM})$
- Can be generalize to GR (TOV)
- Leung (2013) assumed DM particle mass larger than 1 GeV
- Explode with PTD model – Explain some Type Ia

How about other model (DDT) for an extended DM component?