white dwarf astronomy with machine learning

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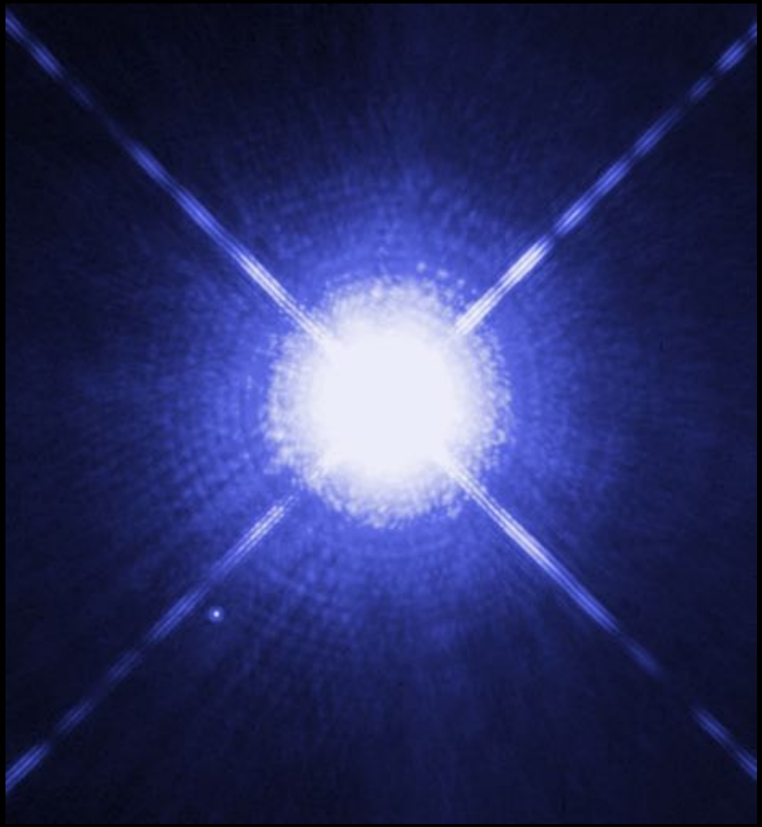
why study white dwarfs?

fate of > 95 % of the stars in our galaxy

extremely dense (1 M_{SUN} in 1 Earth radius)

progenitors of type 1a supernovae?



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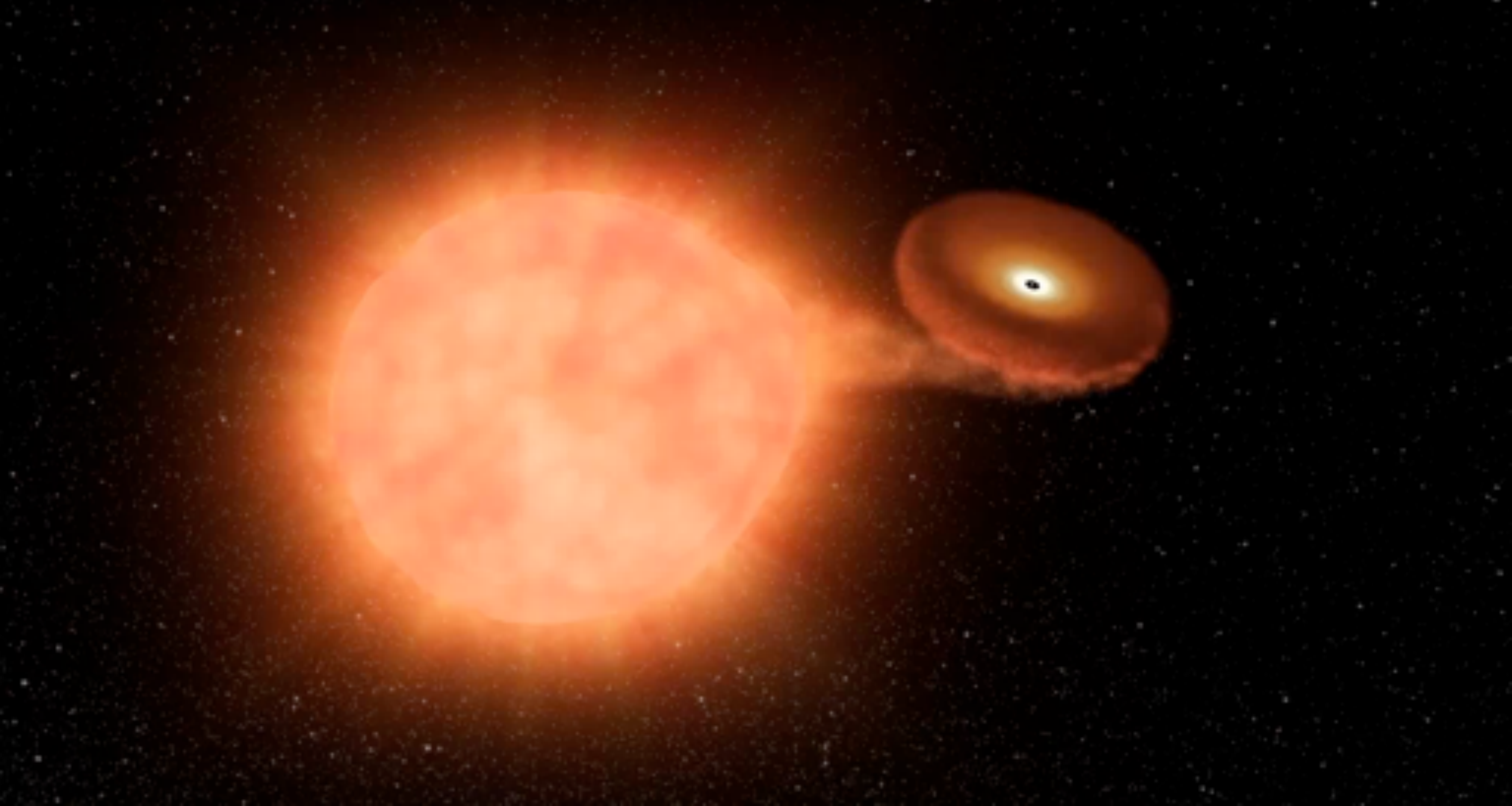


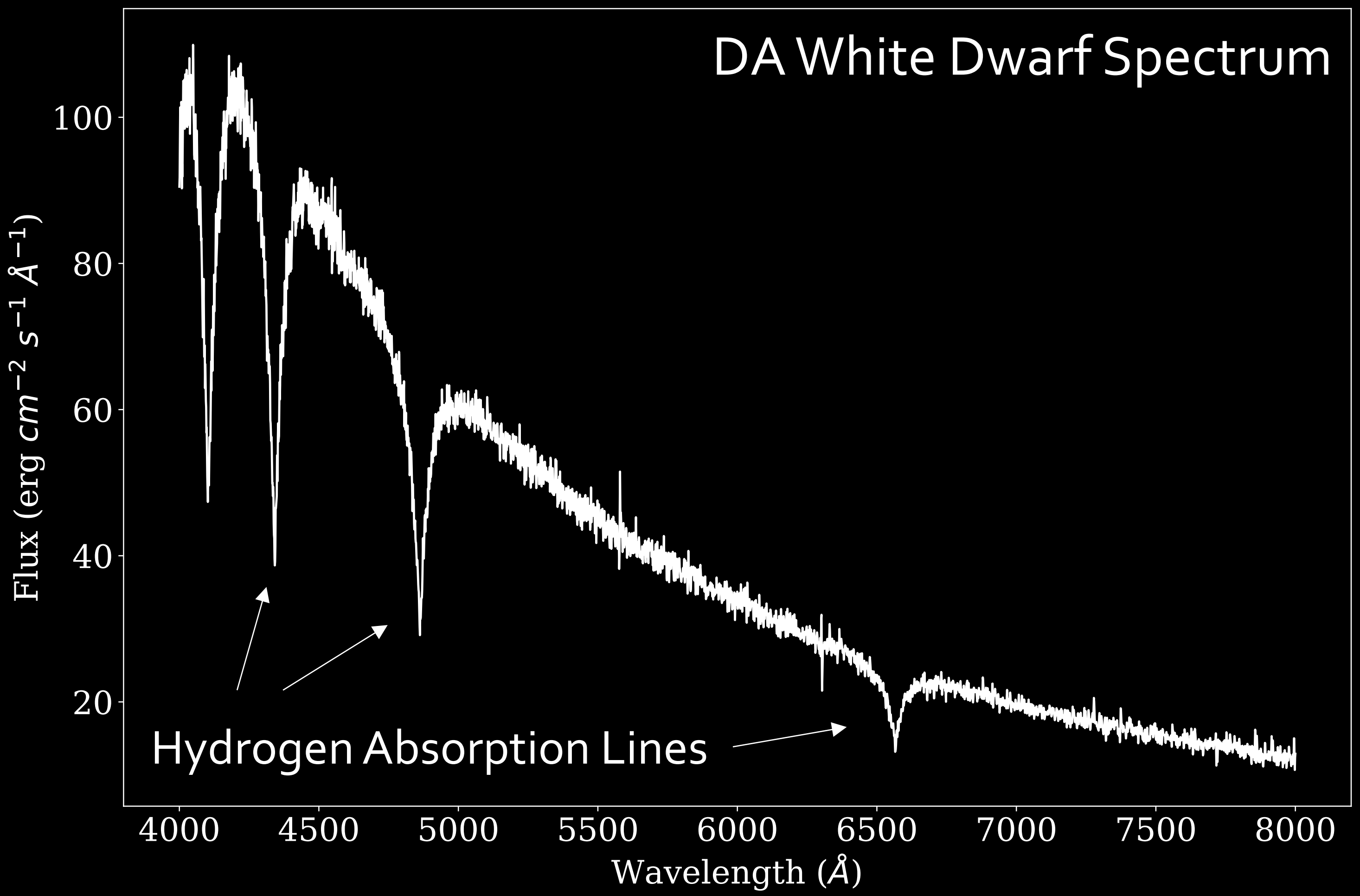
my research questions

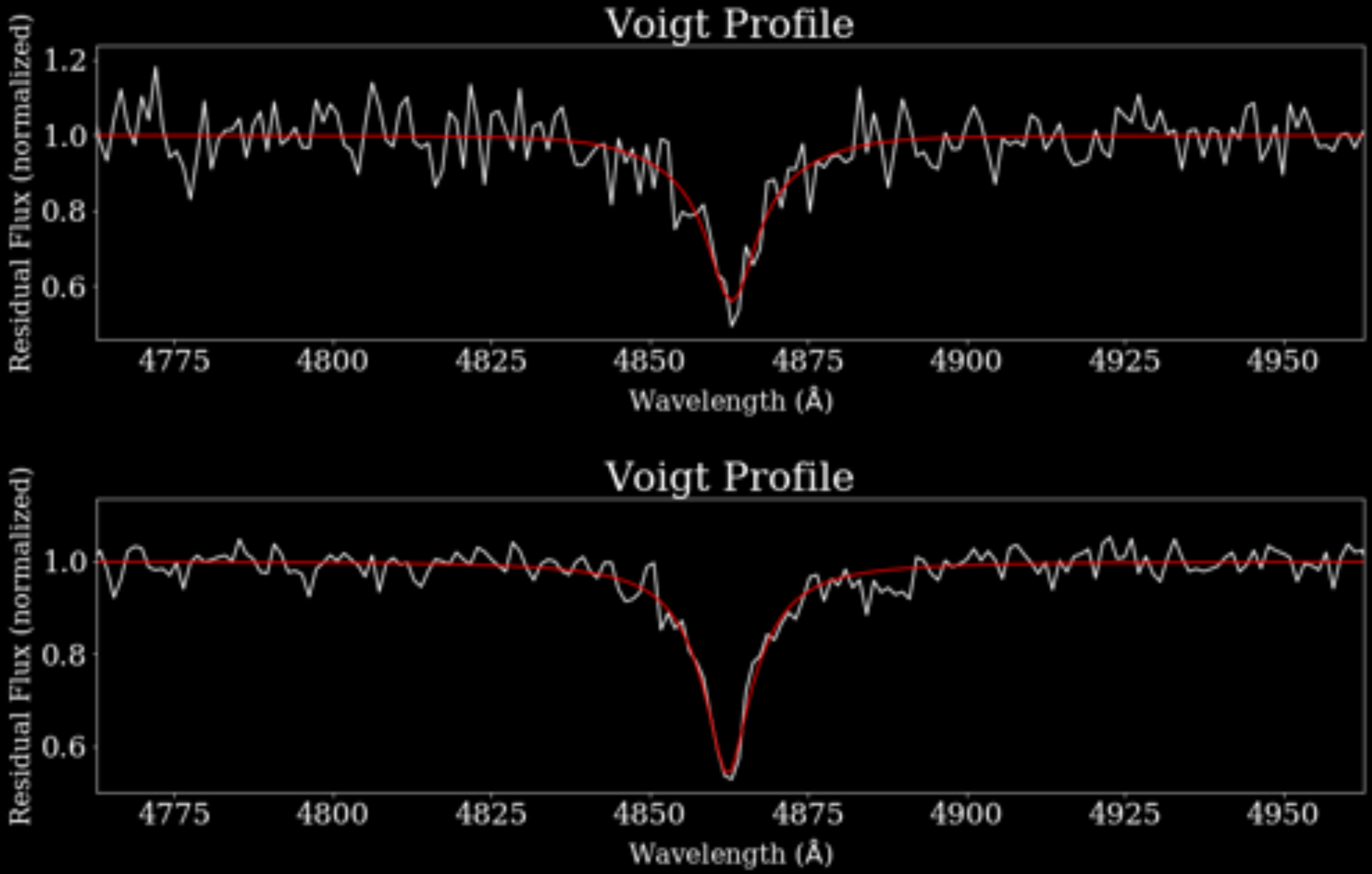
determine stellar labels – mass and surface gravity – from the sparse spectra of white dwarfs

use big data to find exotic candidate stars – massive stars, variable stars, and binaries

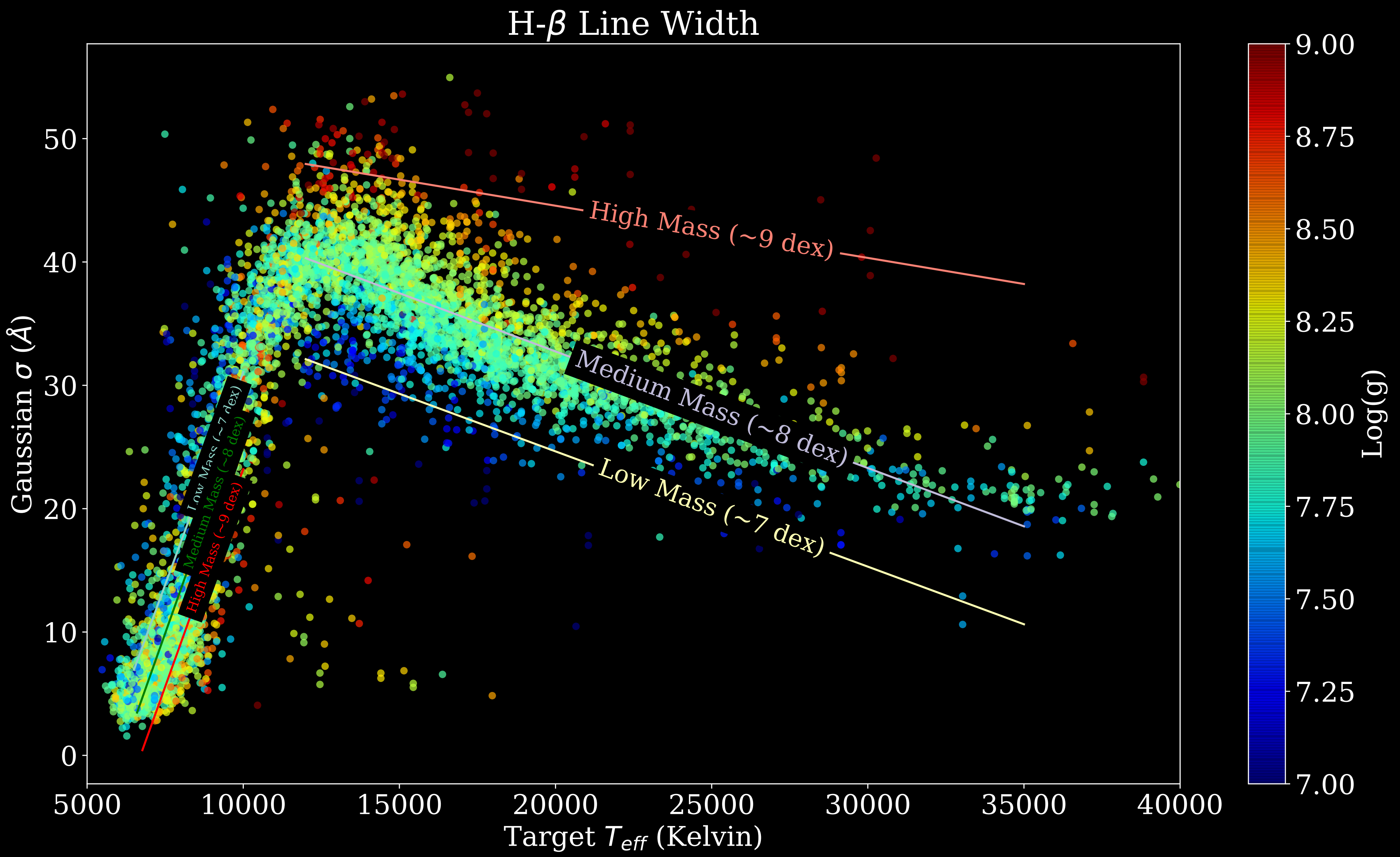
bring these together to explore the cause and characteristics of supernovae

spectroscopy – stellar fingerprints





Voigt Profile
Residual Flux (normalized)
1.2
1.0
0.8
0.6
4775
4800
4825
4850
4875
4900
4925
4950
Wavelength (Å)
Voigt Profile
Residual Flux (normalized)
1.0
0.8
0.6
4775
4800
4825
4850
4875
4900
4925
4950
Wavelength (Å)


H-β Line Width
Gaussian σ (Å)
Target T_{eff} (Kelvin)
Log(g)
High Mass (~9 dex)
Medium Mass (~8 dex)
Low Mass (~7 dex)
0
10
20
30
40
50
5000
10000
15000
20000
25000
30000
35000
40000
7.00
7.25
7.50
7.75
8.00
8.25
8.50
8.75
9.00

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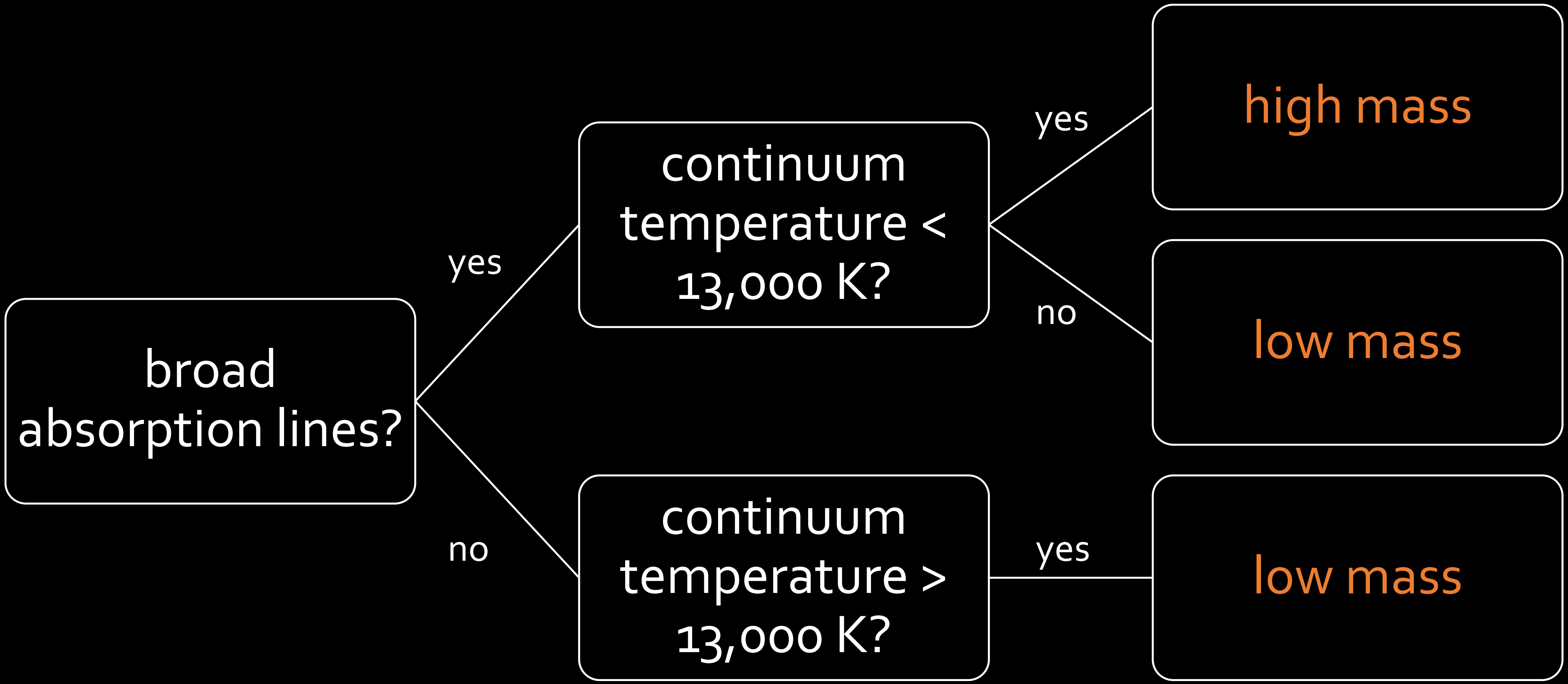
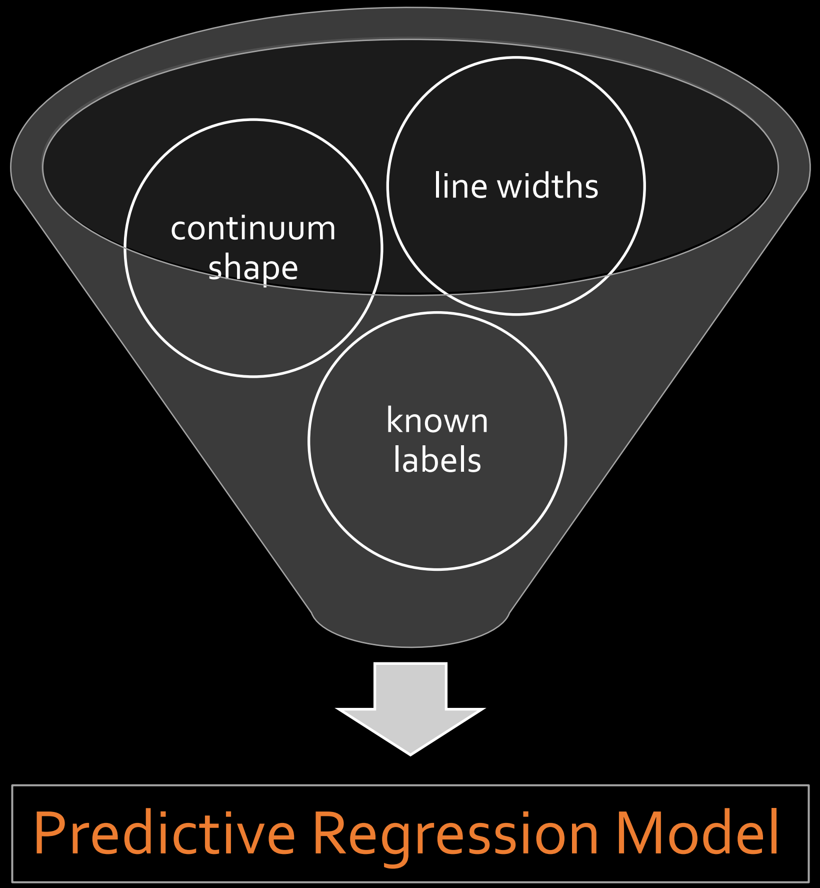
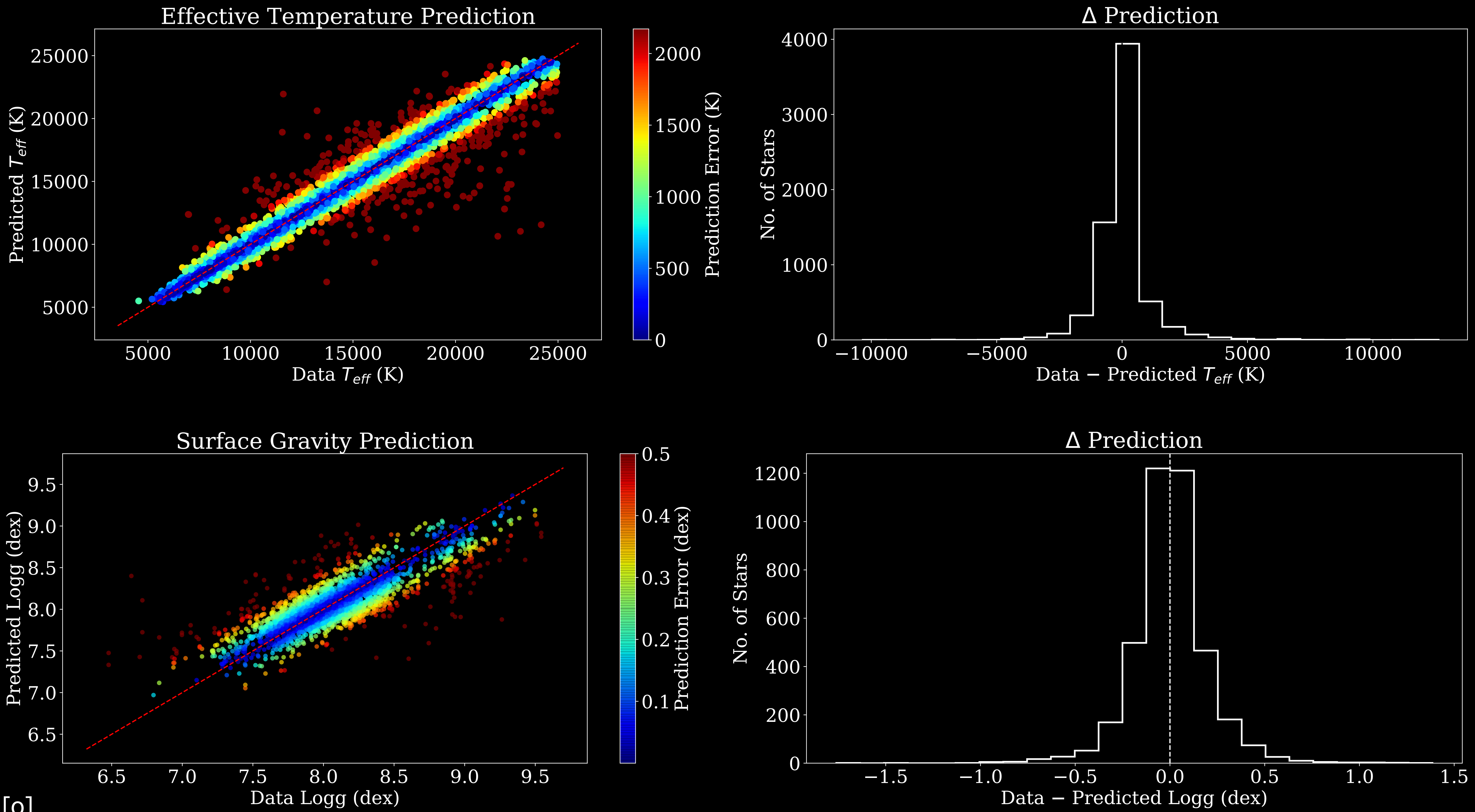
decision trees



random forest regression model





Effective Temperature Prediction
Predicted T_{eff} (K)
Data T_{eff} (K)
Prediction Error (K)
Δ Prediction
No. of Stars
Data − Predicted T_{eff} (K)
Surface Gravity Prediction
Predicted Logg (dex)
Data Logg (dex)
Prediction Error (dex)
Δ Prediction
No. of Stars
Data − Predicted Logg (dex)

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conclusions

random forest regression:

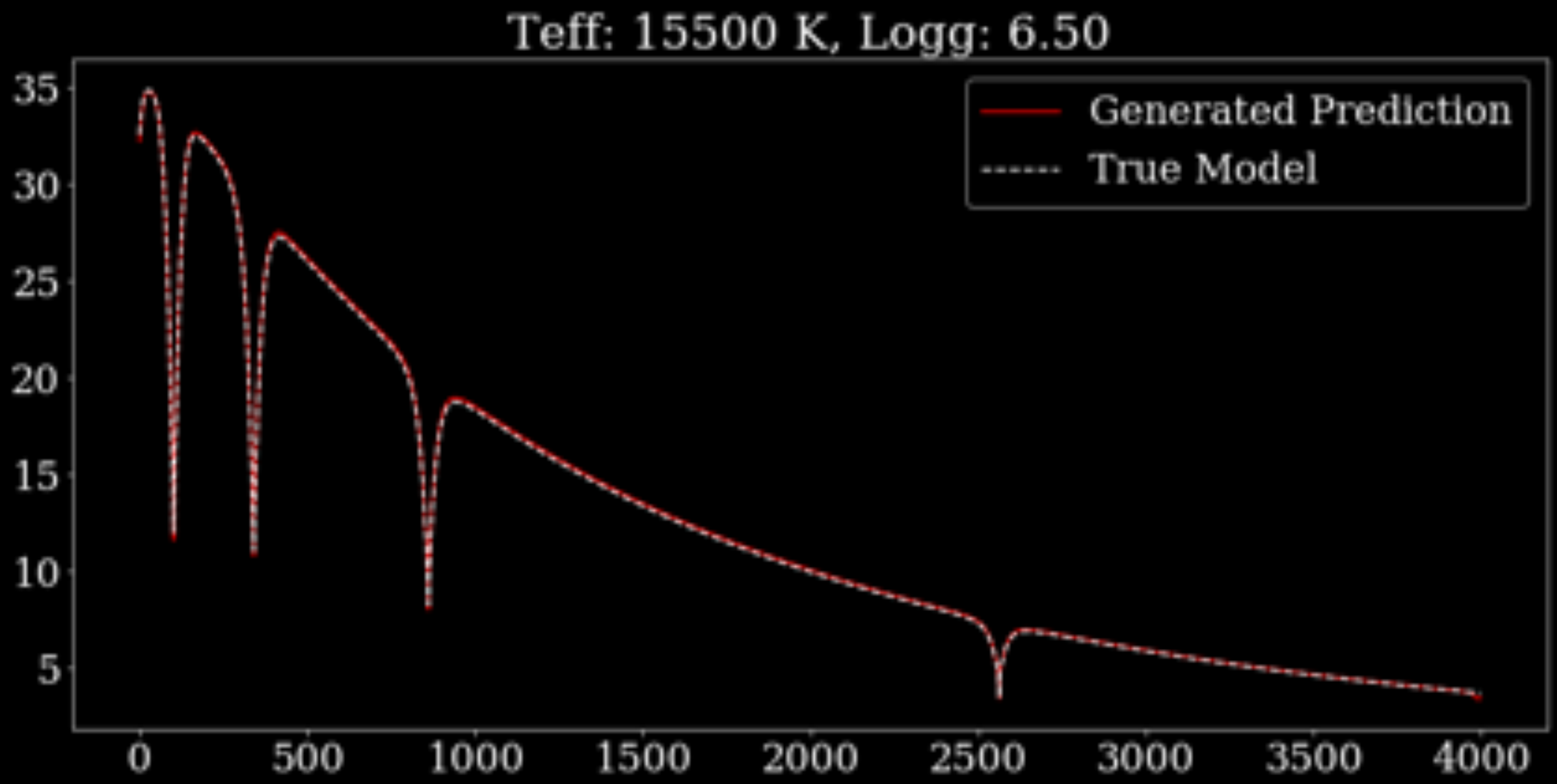
recover temperature labels within ± 500 Kelvin

recover surface gravity labels within + 0.2 dex

more advanced methods show promising results!

future

generative neural network from ab-initio theoretical models



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references and media

[0] own work

[1] chandra.harvard.edu

[2] Hubble Space Telescope

[3] VideosFromSpace (YouTube)

[4] Tremblay and Bergeron, 2009 (ApJ 696.2.1755)