Wesleyan University | The Honors College

Necroplanetology: Dead Planets Are Fun

by

Girish Duvvuri
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Well Shit.

–Varric Tethras

Dragon Age Inquisition

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Chapter 1

Introduction

Background Info on white dwarfs and exoplanetary systems:

1.1 Exoplanets

Rise of the field, importance for understanding diversity of planetary systems Context for pulsar planet as first exoplanet detection, lead in to post-stellar evolution objects.

Work notes: mostly text, lit review.

1.2 Transits

Introduction to transit method (not very long) Discussion of why WDs are favorable for transit detections: comparison figure of lightcurves for Earth transiting Sun vs WD

Work notes: mostly text, lit review. Make one figure.

1.3 WD Transit Motivation

Debris disks+ Polluted WDs: frequency, sinking timescales, overview of past work as motivation for transit studies. We know there are planetary remnants there. K2 mission and guest proposals.

Work notes: Text. lit review + go over other K2 guest proposals.

1.4 WD1145 Detection

Details regarding detection and a little information about followup photometry (more in Chapter 3). Then Xu et al. (2016) detection of circumstellar absorption, leads into discussion of next section.

Work notes: Do some work with available K2 photometry papers to find the best way to summarize object's behavior. Pick out a stellar line to show CS absorption clearly: strong, isolated, preferably from Xu data to show blue and red edges. Or a more large-scale view like Xu et al. (2016) Fig 1a/b?

1.5 Significance of WD1145

Explanation of lack of knowledge of planetary interiors: RV + transit constrain Mass/Radius $\implies$ ρ, transit and eclispse spectroscopy give atmospheric info, but now we use WD as our mass spectrometer to get information about planetary interior. To give context, list some other known disintegrating planetary systems or other ways we've constrained composition (find the iron exo-Mercury that was identified because its orbital period requires that composition to avoid the disintegration we see here)

Work notes: lots of lit review (bring in work with disks, but not too much because that will get discussed more in Chapter 2)

1.6 Figure+Citation

Look figure + citation: (e.g., Vanderburg et al. 2015, see Fig. 1.1).

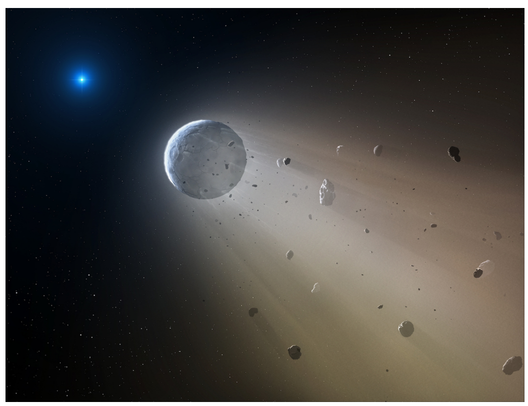

Figure 1.1: The artist rendition of WD1145+017 (from Vanderburg et al. 2015).

Chapter 2

Spectroscopy

More info about previous work done with polluted WDs, but then move on to summary of: we see material in multiple ions, absorption is variable over multiple timescales.

2.1 Datasets

Info about different datasets obtained: time, duration of observations, instrumentation, reduction pipeline, special note about the dataset that coincided with a transit during the March dataset (link back to a figure in Chapter 3 showing this transit if possible).

Work notes: Mostly text, might have to dig into the reduction pipelines and try it for yourself. If we have HST data by then (ask Seth if it is public) talk to Seth+Julian about reduction process. Also find out if that proposal for simultaneous HST+Spitzer+VLT data ended up working out. Is that information (whether it was awarded) publicly available? If yes, which have accessible data?

2.2 Fitting WD+CS

2.2.1 WD

Look at Koester paper (find citation) about details of fitting method and this object specifically. Compare to Xu et al. (2016) and note any differences + what those differences and intrinsic uncertainties imply for conclusions we draw.

2.2.2 CS

Talk about stellar model interpolation and subtraction (if you come up with a more sophisticated way to handle removing the stellar component, replace with that. Incidentally, should look more into that. Roy also works with accreting things right? Maybe he knows other things that people try?)

Discuss trapezoidal model and what different parameters indicate while referring to a typical best-case unblended line. Find a good blended line to show where/why trapezoid fails. Then if you find a line with particularly interesting structure (double-peaked etc.), show that and talk about implication. Point out dropoff of v_{max}.

Also try the Fourier transform Gaussian thing Seth mentioned for ISM work and if that ends up being a meaningful result, talk about. (Need to try it out to see if it is worth elaborating on). Look at other papers from Xu + other polluted WD people to see if they do anything special for CS absorption.

Work notes: Look into the simultaneous CS+WD fitting thing someone mentioned in the paper email chain and see if that actually means anything feasibly doable. The code for the majority of the CS fitting work is already done, just a matter of fine-tuning and adding on the extra things described above if they turn out to be worth doing.

2.3 Ions

Look at things on the broader scale: EWs, abundances and column densities of different species averaged over all datasets or for one specific dataset. Comment on relation to bulk Earth / chondrites and other polluted WDs.

Work notes: Learn how to actually calculate abundances. Column density code is fine.

2.4 Variability

Discuss trend in variability over datasets we've seen, see if you can quantify shifts for a particular ion by looking at EWs and $v_{min,max}$. Compare to the disk CS variability paper that just went on arxiv: Manser et al. (2016)

Work notes: See if any trends exist.

2.5 Disk Modeling

Talk about various options, show examples of toy models. Then talk about Wilson's model and try working with it yourself.

Work notes: Haven't done any of this, read papers and talk to Wilson to see what you can do.

Chapter 3

Photometry

3.1 Introduction

Talk about diversity and irregularity of signals seen, compare to Alien Zombie Comet star and a couple of other weird ones, particularly other disintegrating planet transits. Discuss the different periodicity analyses done by different groups (for K2, point out difficulties with spacecraft readjustment) and drifting periods in relation to TTVs and other phenomena if they exist (do more reading). Waterfall plot.

Work notes: Mostly just text and reading.

3.2 Datasets

Talk about all datasets you're using (if 24" data ends up working, talk about WD Transit Survey in detail, else ignore): the usual book-keeping of instruments, observing strategies, etc.

Work notes: Mostly text, reading, Data Thief.

3.3 Multi-bar Cloud Model

Talk about bar cloud model as extremely simplified way to look transit signals.

One version that takes an apparently single isolated transit and fits one cloud moving across it to vary τ, width w, length l, impact parameter b. Do this for as many such isolated signals as you can find to inform priors for those parameters. Depending on how useful this ends up being, you can turn into a functional prior or just to set bounds on a uniform or log-uniform prior for the next bit. When starting this one, use a log-uniform prior for τ, w, l.

Then use those priors for a version that uses N_{clouds}, each with their own τ, w, l, b (Might end up fixing this at $i = 90°$),and period P to fit an extended lightcurve with multiple transit signals.

Work notes: Expand this into more sections as work on it progresses. None of this has been done and I don't know how much of it can actually be done. We'll find out. Note: if it ends up being better, turn τ into two things: a τ_0 for the head of the bar and a τ decay rate, crudely approximating a comet. Or, stick with just the τ_0 and adjust the decay rate to go to 0 at the end of the bar. Might help with asymmetric signals. The pseudocode for all this is pretty simple in my head, but it will probably end up being a nightmare to implement any of it.

Chapter 4

Nbody

Behold.

4.1 Background

Discuss past work done by Veras, Leinhardt, Debes. The problem of how to move an asteroid into a tidally disrupt-able orbit (Veras uses long-period highly eccentric orbits, Debes places a Jupiter to bump circular asteroid into instability). Say we just start at currently observed orbit and comment on possible inconsistencies there.

4.2 REBOUND

Discuss the package, importance of including collisions, any other work that uses it. Talk about how it handles collisions and choice of integrator method+timesteps.

4.3 Initializing Object

Using abundances from Chapter 2, devise different cross-sections for a total mass consistent with observed accretion rate. Talk about Kepler conjecture and problem of packing with differently sized particles. Justify choice of keeping all equally sized by radius and only varying mass. Compare cross-section diagram with rings to the cross-sections of generated asteroid/planetesimals.

4.4 Evolve Orbit

Experiment with different timesteps with the maximum computationally doable N and evolve the orbit. At significant stages, evolve on much shorter timesteps and generate lightcurves (if possible). If/when it hits some kind of steady-state, comment on end-stage for system.

4.5 Collisions

Using all recorded collisions and Blum and Wurm etc. papers (e.g., Beitz et al. 2016; Deckers et al. 2015) determine dust ejecta formation rate and compare to observed accretion rate. Some ratio could be determined and explained by a balance between gravity, magnetospheric attraction, radiation pressure blowout if you assume a size+mass distribution and that all interactions will be dominated by the WD. Maybe that's a stretch, but at least you can compute a ratio.

Work notes: The code for the setup is done, the problem is just running it for longer with $> N$ and figuring out how to put it on the cluster. Also the collision section, I haven't checked to see how much checking for collisions affects the code speed.

Appendix A

Nonsense

Appendices are TEXnically indistinguishable from normal chapters.

Subsections are Possible?

Apparently.

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