A sinking feeling: Investigating the relationship between team eDensity and Level

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ABSTRACT *Team eDensity is intricately linked to an ILB team's Level, their Credit to the League. Game data available from Seasons 12–14 helps us develop a model for understanding how Levels change over time. The names given by the game to this data implies a physical relationship and provides us with some minimal room for conjecture on cosmology of the immaterial plane. This relationship additionally informs us of a subset of the consequences of returning Chorby Soul from the Trench.*

KEYWORDS
Phys. objects
Phys. concepts
Cosmology
Necromancy

INTRODUCTION

In the first On Season of Blaseball's Expansion Era, the game introduced a number of new concepts. Two new values, *eDensity* and *Level*, are intricately linked to a new game mechanic that reduces player ratings randomly for teams that generally perform better than other teams, behaving like an anti-Party Time mechanic.

In the game, eDensity presents itself as an opaque number in units of bl/m^3; Level is described as "a measurement of this Team's Credit to the League", and displays text most similar to bond credit ratings. Teams below "C" Level begin to have a chance of being attacked by consumers, represented in-game by sharks.

Although eDensity and Level are clearly related in some fashion, the mechanism through which they are related is extremely convoluted and still not fully understood. We reverse engineer how both *player eDensity* and *team eDensity* are calculated and how these are used to calculate *eVelocity* and *imPosition*, variables present but hidden in Seasons 12–13 and removed in Season 14. We discuss the relationship between a team's Level and its imPosition, the information we can infer about immaterial plane cosmology, and the likely effect of Chorby Soul on the Seattle Garages in Season 15.

DEFINITIONS

Observations of game data from Seasons 12 and 13 lead to the following definitions of eDensity, eVelocity, and imPosition. Archival data is sourced from Chronicler (SIBR 2021a) and Datablase (SIBR 2021b); the coefficients in the eVelocity formula were partially determined by using SageMath (The Sage Developers 2021).

Each player in ILB has an eDensity (ρ^e) value, currently consisting of their total player rating, soul, number of Ego Boosts (e.g. Ego++ is 2 Ego Boosts), and whether they have Perk:

$$\begin{aligned}\rho^e_{player} =& totalRating \times 7 + soul \times 2 \\ &+ \#ego \times 6.5 + \#perk \times 26\end{aligned}$$

The total rating is the sum of the player's batting, pitching, baserunning, and defense ratings, regardless of their position. Ratings are calculated such that a rating of 0.2 is exactly equivalent to 1 star in a given category.

Team eDensity adds together the player eDensities across their lineup, rotation, and shadows, then adds values based on the number of championships, net shame (total shamings minus total shames), runs, wins, and ballpark filthiness, grandiosity, and fortification. In Seasons 12–13, the eDensity formula was the following:

$$\begin{aligned}\rho^e_{team} =& \sum \rho^e_{player} + runs + wins \times 10 \\ &+ netShame \times 5 + \#champs \times 99 \\ &+ grand \times 5 + fort \times 5 \\ &+ filth \times 500\end{aligned}$$

In Season 14, the eDensity formula was changed, which deemphasized championships and increased the effect of ballpark attributes. Ballpark modifications (such as Peanut Misters, PsychoAcoustics, or Big Buckets) are now also included:

$$\begin{aligned}\rho^e_{team} =& \sum \rho^e_{player} + runs + wins \times 10 \\ &+ netShame \times 5 + \#champs \times 33 \\ &+ grand \times 100 + fort \times 100 \\ &+ filth \times 500 + \#parkmods \times 100\end{aligned}$$

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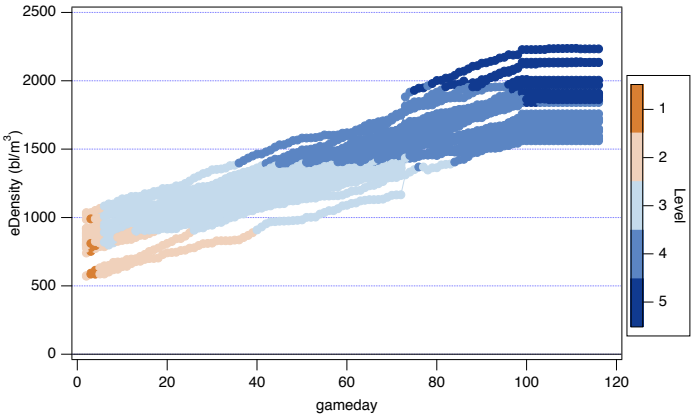

Figure 1 Season 14 eDensity for all teams, as a function of gameday. Points are colored according to Level. Level seems to roughly correlate with eDensity, but especially early in the season, there is a lot of Level variation that cannot be explained just with eDensity.

Player and team eDensities are both available from game data, and team eDensity is displayed in the game itself.

In this paper we define *noodle* as the position on the Idol Board where the MVP Line displays during the regular season. This value is defined by the `strictlyConfidential` field in game data; the top *noodle* + 1 players receive Ego Boosts at the end of each season.

eVelocity (v^e) and imPosition (x^I) are defined as the following recursive formulas:

$$\begin{aligned} v_i^e =& 0.55 \times (v_{i-1}^e - x_{i-1}^I - 0.0005 \times \rho_i^e \\ & - 0.0388 \times noodle + 0.9992) \\ x_i^I =& x_{i-1}^I + v_i^e \end{aligned}$$

each starting at 0 at the beginning of Season 12.

Player eDensity, team eDensity, eVelocity, and imPosition are all calculated at the beginning of each new day in Blaseball, except for the first day of a season[1]. Team eDensities drop significantly on Day 2 as the previous season's wins and runs are forgotten; eVelocities and imPositions carry over from the previous season.

DISCUSSION

eDensity and Level

By graphing eDensity (Figure 1), eVelocity (Figure 2), and imPosition (Figure 3) across the league for Season 14 with data points colored based on Level, we draw the conclusion that imPosition seems most closely related to a team's Level. Note that these figures use a numerical Level that maps to the "bond ratings" displayed on the team info pages. As Level goes from 1 to 5 (and beyond), the displayed rating goes 1D, 2D, 3D, C, Low A (and beyond).

Despite the slightly clearer boundaries in imPosition data, the thresholds for each level are still not clear. Figure 4 shows a graph with imPosition adjusted by adding *noodle*/10, which significantly smooths out data in the later days of the season; our best operating theory at time of publication is that the level thresholds depend on the same thing the MVP Noodle depends on, perhaps in an unrounded form, and that the effects of moving Liquid Friend and Uncle Plasma above the Noodle toward the end of the Lateseason fluctuated level thresholds significantly.

[1] On the first day of the season, we rejoice.

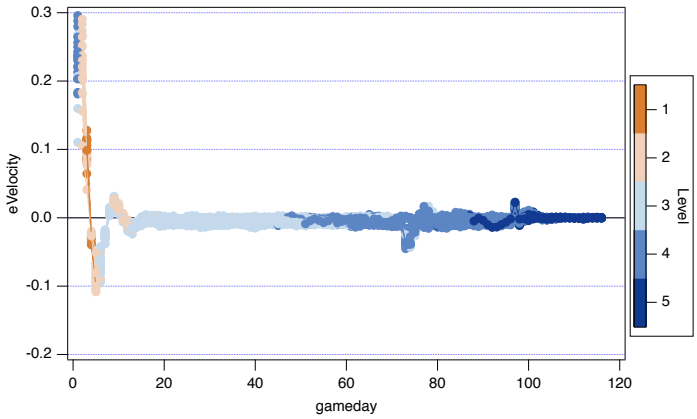

Figure 2 Season 14 eVelocity for all teams, as a function of gameday. Points are colored according to Level. Level does not seem directly correlated with eVelocity at all.

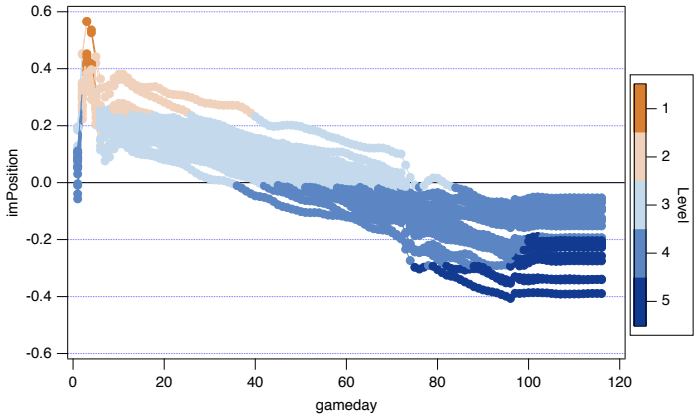

Figure 3 Season 14 imPosition for all teams, as a function of gameday. Points are colored according to Level. Level seems to correspond to imPosition better than it matches changes in eDensity or eVelocity.

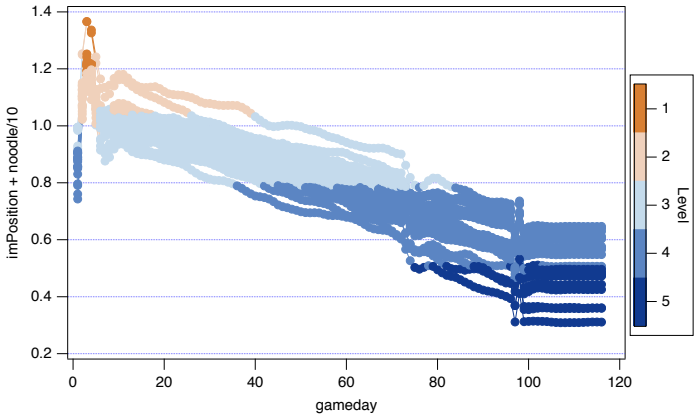

Figure 4 Season 14 adjusted imPosition + *noodle*/10 for all teams, as a function of gameday. Points are colored according to Level. This seems to mostly flatten out the transition from level 4 to level 5 (C to Low A), compared to Figure 3.

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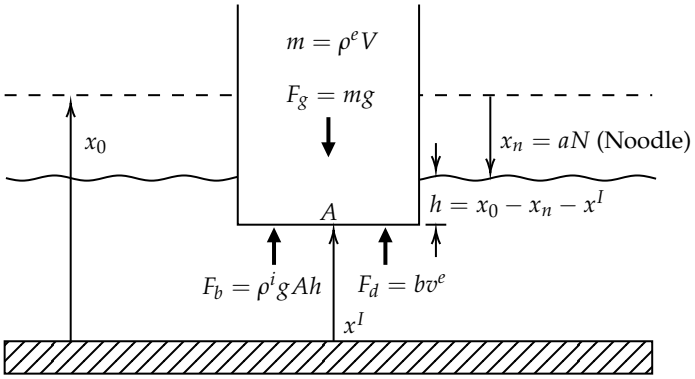

Figure 5 Force diagram of a physical interpretation of the eDensity/eVelocity/imPosition problem. The team is represented by a constant-cross-section object of uncertain height (tall enough to never be fully submerged) floating in a fluid of immateria whose level can vary according to the Noodle. The team is subject to gravitational force (proportional to mass, and thus to eDensity), buoyant force (proportional to the submerged depth h, and thus imPosition), and fluid drag (proportional to eVelocity).

Because we have no official league data with both Level and imPosition at the same time, it is unfortunately possible that the formulas to calculate imPosition changed subtly between Seasons 13 and 14. Short of official confirmation, we would have no way to determine if this is the case, and we are continuing to research under the assumption that this did not happen.

Cosmological inference

The nature of the immaterial plane has always been difficult to understand from our material perspectives. Fortunately, the discovery of eDensity and imPosition has given us a window into the fundamental nature of immaterial plane physics.

Following the principles of linguistic determinism[2], we interpret imPosition as "immateria position." We know that many things such as runs and wins are physical objects, so we suppose that each team is itself a physical object. The immateria acts as a fluid (as suggested by Flooding weather), and therefore exerts buoyant and drag forces on physical objects it comes into contact with.

Interpreting the eVelocity and imPosition formulas in this framework brings a clear picture into view. We picture a team as a container (for simplicity, a cylinder[3] of unknown height) floating in a fluid, subject to the forces of gravity, buoyancy, and fluid drag. Figure 5 illustrates the situation. Using this notation, the equation of motion for the team object is:

$$m\frac{d^2x}{dt^2} = -b\frac{dx}{dt} - \rho^i g A x + \rho^i g A \left(x_0 - aN - \frac{V}{\rho^i A}\rho^e\right),$$

$$\text{or} \quad m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + k\,(x - C) = 0\,.$$

Here, $k = \rho^i g A$, and $C = x_0 - aN - \frac{V}{\rho^i A}\rho^e$. This is a damped harmonic oscillator with equilibrium position C. A team's imPosition (if offset from equilibrium) will therefore oscillate about C in an exponentially-damped sinusoid until it settles. The equilibrium position is made up of three terms: a constant (arbitrary) offset x_0, an offset based on the "water level" aN, and an offset based on the force of gravity on the object $mg/k = \frac{V}{\rho^i A}\rho^e$. If any of these terms change, the object will seek the new equilibrium position in the same way it found the old. In our system of interest (a blaseball team), eDensity changes rapidly once at the beginning of the season, and then steadily throughout the rest of the season. Because "immaterial buoyancy" acts as an imPosition-dependent balancing force, once the team object reaches a rough equilibrium between the forces due to eDensity and imPosition, the rate of decline depends mostly on the seasonal increase in eDensity.

This physical analogy is compelling, but when compared to the actual formula, does it hold water (or immateria, for that matter)? We can rewrite the formula for eVelocity to give "eAcceleration", or change in eVelocity between steps. This (plus some regrouping of terms) gives the following form:

$$\begin{aligned} v^e_i - v^e_{i-1} = &-0.45 v^e_{i-1} - 0.55 x^I_{i-1} \\ &+ 0.55\,(0.9992 - 0.0388 \times noodle - 0.0005\rho^e_i) \end{aligned}$$

This form is *almost* identical to our equation of motion. We have a drag coefficient of 0.45, a "spring constant" of 0.55, and an equilibrium position of $0.9992 - 0.0388 \times noodle - 0.0005\rho^e_i$. However, we are missing a "mass" term m. We could say that $m = 1$, but this conflicts with how we defined $m = \rho^e V$: if mass is constant, then changing eDensity has to be offset by decreasing volume, and the mg/k term in the equilibrium position won't change. But we know from examining the data that a team's eDensity changes almost every game, and this change causes a steady change in imPosition! So the mass cannot be constant.

The only reasonable conclusion to draw from this conundrum is that the relationship between mass and density in the immaterial plane must be different than it is here in the material plane. This deserves further study beyond what we have time for right now. One interesting note along these lines is that shame factors into the eDensity formula. The Glossary in the Book ([redacted] et al., ????) defines shame as a physical concept (as opposed to a physical object like Runs or Wins), so this implies that physical concepts have density in the immaterial plane. The eDensity formula also implies that filthiness is either a physical concept or a physical object, though it is unclear which. It is clear, regardless, that further study into immaterial physics and cosmology will have important ramifications to our understanding of the splort of blaseball.

Effects of soul outliers

The necromancy of Chorby Soul in the Season 14 Election was likely caused by some of this initial research indicating that a player's soul value now has some level of impact on a team. While most players have a soul value in the 1–10 range, Chorby Soul has 1777 soul. Moving Chorby onto Seattle's pitching rotation led The Game Band to patch a long-standing game bug that resulted in the soulscream derivation function dividing a value by zero, crashing some browsers.

A player's soul is doubled and added to their eDensity, then added to their team's eDensity. Based on our definitions, the projected eDensity of Chorby Soul at the beginning of Season 15 is 3565.79693, more than double the Garages' end-of-season eDensity, and more than any end-of-season eDensity for any team in ILB.

The projected eDensity of the Seattle Garages at the beginning of Season 15 is therefore 4428.6202 (although this value may not display on the site, as eDensities are not recalculated on Day 1, and Day 2's eDensity will contain any runs or wins earned in the previous game). From this analysis, we can conclude that Seattle's

[2] The first principle of blaseball linguistic determinism: everything that could be a pun, is a pun.

[3] Or, if you like, a prism whose horizontal cross-section is the shape of a baseball diamond.

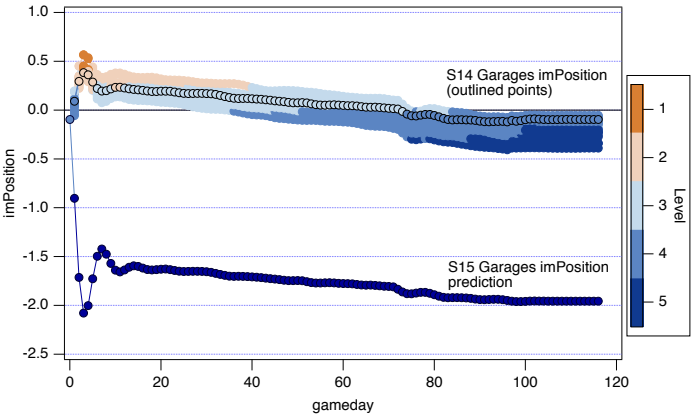

Figure 6 Seattle Garages projected imPosition, compared to their season 14 imPosition (and that of all the other teams; these are all identical to Figure 3). The projection was calculated by starting with Seattle's final eVelocity and imPosition of season 14, and calculating forward with the assumption that their eDensity in season 15 follows the exact same trajectory as it did in season 14, but with Chorby Soul's eDensity added to it.

eDensity will be the only one to increase while all others decrease as eDensities are recalculated in Season 15. Instead of bouncing back to safer levels of 2D and 3D at the beginning of the season, the Garages will in all likelihood start the season at C level, quickly drop to (or past) Low A and continue to drop further from there, as depicted in Figure 6. After this initial "shock," the rate of decline for the Garages should depend mainly on their rate of in-season eDensity accumulation, just like every other team, but it will be happening at a much lower (and likely more dangerous) level.

FUTURE RESEARCH

As we obtain more data through Season 15, we hope to accurately determine the relationship between imPosition and Level, likely by determining what causes changes in the MVP Noodle position on the Idol Board, and determine if consumer attacks are more likely when a team is at a lower imPosition.

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APPENDIX A: PROOF OF IMPOSITION CONVERGENCE (FOR FIXED EDENSITY AND NOODLE)

Let $f(x,v) = (x + 0.55(v - x + C), 0.55(v - x + C))$ represent the imPosition and eVelocity update function, where $C \in \mathbb{R}$ is some fixed constant. We wish to show that f applied to any starting values $x_0, v_0 \in \mathbb{R}$ converges to $(C, 0)$.

Note that f is an affine transformation. We can rewrite f as a single matrix multiplication as follows:

Let

$$F = \begin{bmatrix} 0.45 & 0.55 & 0.55C \\ -0.55 & 0.55 & 0.55C \\ 0 & 0 & 1 \end{bmatrix}$$

Then note that

$$F \begin{bmatrix} x \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} 0.45x + 0.55v + 0.55C \\ -0.55x + 0.55v + 0.55C \\ 1 \end{bmatrix} = \begin{bmatrix} f(x,v) \\ 1 \end{bmatrix}$$

where we interpret $f(x,v)$ as a vector of length 2.

Since the third component isn't changed, multiplying by F again will apply f again to our input.

Let f^n be the nth iterate of f. We then have

$$F^n \begin{bmatrix} x \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} f^n(x,v) \\ 1 \end{bmatrix}$$

We now diagonalize: $F = PDP^{-1}$ where

$$P = \begin{bmatrix} C & \frac{1+2i\sqrt{30}}{11} & \frac{1-2i\sqrt{30}}{11} \\ 0 & 1 & 1 \\ 1 & 0 & 0 \end{bmatrix}, D = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} - i\sqrt{\frac{3}{10}} & 0 \\ 0 & 0 & \frac{1}{2} + i\sqrt{\frac{3}{10}} \end{bmatrix}$$

Thus,

$$\begin{bmatrix} \lim_{n\to\infty} f^n(x_0, v_0) \\ 1 \end{bmatrix}$$

$$= \lim_{n\to\infty} \begin{bmatrix} f^n(x_0, v_0) \\ 1 \end{bmatrix}$$

$$= \lim_{n\to\infty} F^n \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix}$$

$$= \lim_{n\to\infty} (PDP^{-1})^n \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix}$$

$$= \lim_{n\to\infty} PD^nP^{-1} \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix}$$

$$
\begin{aligned}
&= \lim_{n\to\infty} P \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} - i\sqrt{\frac{3}{10}} & 0 \\ 0 & 0 & \frac{1}{2} + i\sqrt{\frac{3}{10}} \end{bmatrix}^n P^{-1} \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix} \\
&= \lim_{n\to\infty} P \begin{bmatrix} 1^n & 0 & 0 \\ 0 & \left(\frac{1}{2} - i\sqrt{\frac{3}{10}}\right)^n & 0 \\ 0 & 0 & \left(\frac{1}{2} + i\sqrt{\frac{3}{10}}\right)^n \end{bmatrix} P^{-1} \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix} \\
&= P \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} P^{-1} \begin{bmatrix} x_0 \\ v_0 \\ 1 \end{bmatrix} \\
&= \begin{bmatrix} C \\ 0 \\ 1 \end{bmatrix}
\end{aligned}
$$

so $\lim_{n\to\infty} f^n(x_0, v_0) = (C, 0)$ as desired.