BILL, RECORD LECTURE!!!!

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Van Der Warden's (VDW) Thm

Exposition by William Gasarch

June 2, 2026

VDW's Thm

Def Let $W, k, c \in \mathbb{N}$. Let $\mathrm{COL}\colon [W] \to [c]$. A **mono k-AP** is an arithmetic progression of length k where every elements has the same color. We often say

$$a, a+d, \ldots, a+(k-1)d \text{ are all the same color}$$

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VDW's Thm For all k, c there exists $W = W(k, c)$ such that for all $\mathrm{COL}\colon [W] \to [c]$ there exists a mono k-AP.

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1. Within one block.
2. If we take enough blocks, how they relate.

Within a Block

Def: $a, a+d, a+2d$ is an **almost mono 3AP** if $\mathrm{COL}(a) = \mathrm{COL}(a+d) \neq \mathrm{COL}(a+2d)$. The **color of an almost mono 3AP** is $\mathrm{COL}(a) = \mathrm{COL}(a+d)$.

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Look at the first three elements of a block of 5:

1. **RRR** or **BBB**. 1-2-3 is mono 3AP.
2. **RBR** or **BRB**. 1-3-5 is mono 3AP or almost mono 3AP.
3. **RBB** or **BRR**. 2-3-4 is mono 3AP or almost mono 3AP.
4. **BBR** or **RRB**. 1-2-3 is almost mono 3AP.
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So always get a mono 3AP or an almost mono 3AP. Can assume its almost mono 3AP and its **R**.

$$\boxed{\mathrm{R} \quad \mathrm{R} \quad ?}$$

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Hence need to take $W = 5 \times 65 = 365$.

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We can get by with LESS blocks- we will consider this point after the proof.

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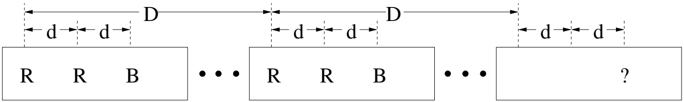

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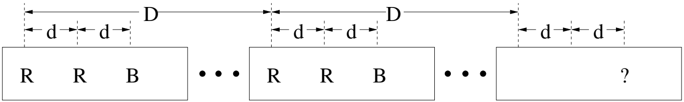

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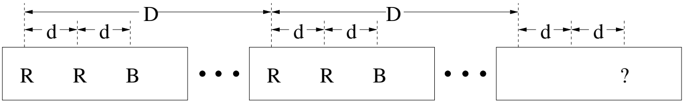

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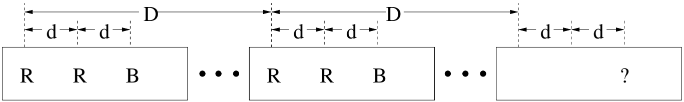

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Is $W(3, 2) = 365$?

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The few known VDW numbers are **much smaller** than the bounds given by the proof of VDW's Thm.

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Need $2 \times 3^7 + 1$ blocks.

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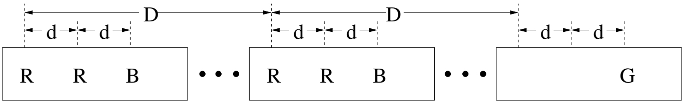

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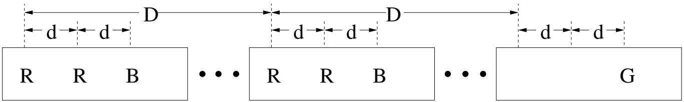

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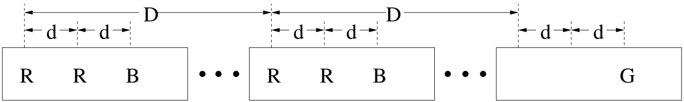

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We have 2 almost mono 3APs of diff colors that same last element.

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2. $\exists$ either a mono 3AP or an almost mono 3AP of blocks.

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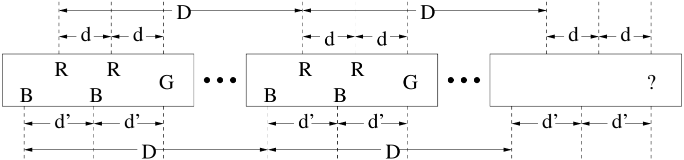

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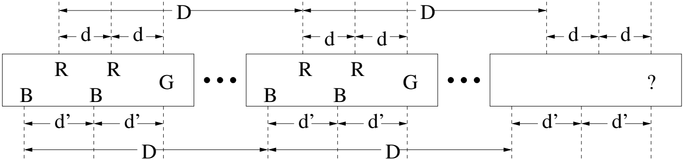

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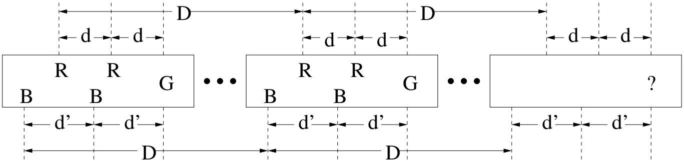

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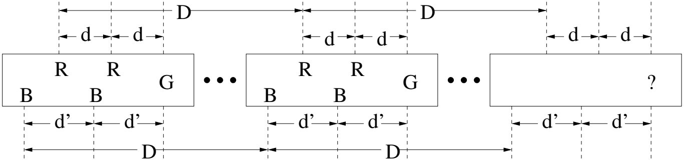

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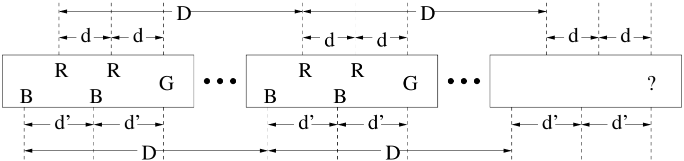

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Done!

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From what you have seen:

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- You COULD do a proof that $W(3, 4)$ exists. You would need to iterate what I did twice.

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- You COULD do a proof that $W(3, 4)$ exists. You would need to iterate what I did twice.
- There are ways to formalize the proof; however, they are not enlightening.

What Did We Use to Prove $W(3,c)$?

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$W(2,X) \implies W(3,4)$ where X is very large.

Note that we **do not** do
$W(3,2) \implies W(3,3)$.

Induction, But On What?

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There are proofs by induction with better bounds, but still quite large.

Yasmine Remembers This Proof from The Course on Ramsey Theory

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I like Big Blocks and I cannot Lie!

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YASMINE You should write a song with that refrain.

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BILL I did!

YASMINE You should write a song with that refrain.

BILL I did!

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BILL I did!

YASMINE You should write a song with that refrain.

BILL I did!

YASMINE Great! Can we hear it?

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BILL I did!

YASMINE You should write a song with that refrain.

BILL I did!

YASMINE Great! Can we hear it?

BILL I will sing it, for some definition of **sing**.

I Like Big Blocks! (Non Chorus)

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

Encode each block by its own pro-file

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

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Encode each block by its own pro-file

Collapse the colors; compress the style

I Like Big Blocks! (Non Chorus)

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Each Block's got a col-o-ring inside

Encode each block by its own pro-file

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Pigeon-hole says types repeat

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

Encode each block by its own pro-file

Collapse the colors; compress the style

Pigeon-hole says types repeat

Now look at blocks, and take a seat.

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

Encode each block by its own pro-file

Collapse the colors; compress the style

Pigeon-hole says types repeat

Now look at blocks, and take a seat.

Ind-uction hums

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

Encode each block by its own pro-file

Collapse the colors; compress the style

Pigeon-hole says types repeat

Now look at blocks, and take a seat.

Ind-uction hums

The gears all click

I Like Big Blocks! (Non Chorus)

We partition N into block so wide

Each Block's got a col-o-ring inside

Encode each block by its own pro-file

Collapse the colors; compress the style

Pigeon-hole says types repeat

Now look at blocks, and take a seat.

Ind-uction hums

The gears all click

omega-squared—What a trick!

I Like Big Blocks! (Chorus)

I Like Big Blocks! (Chorus)

I like big blocks and I cannot lie!

I Like Big Blocks! (Chorus)

I like big blocks and I cannot lie!

You other math folks can't deny!

I Like Big Blocks! (Chorus)

I like big blocks and I cannot lie!

You other math folks can't deny!

With finitely many colors that you choose

I Like Big Blocks! (Chorus)

I like big blocks and I cannot lie!

You other math folks can't deny!

With finitely many colors that you choose

There's a mono AP that you can't refuse.

I Like Big Blocks! (Non Chorus)

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

Doesn't matter– same encore

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

Doesn't matter– same encore

Hide your patterns, try to duck,

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

Doesn't matter– same encore

Hide your patterns, try to duck,

Regularity brings the luck

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

Doesn't matter– same encore

Hide your patterns, try to duck,

Regularity brings the luck

A Length-k run in one shade

I Like Big Blocks! (Non Chorus)

Color red-blue? Or three or more?

Doesn't matter– same encore

Hide your patterns, try to duck,

Regularity brings the luck

A Length-k run in one shade

Its a combinatorial serenade!

I Like Big Blocks! (Final Chorus)

I Like Big Blocks! (Final Chorus)

I like big blocks and I cannot lie!

I Like Big Blocks! (Final Chorus)

I like big blocks and I cannot lie!

Mono APs you can't deny.

I Like Big Blocks! (Final Chorus)

I like big blocks and I cannot lie!

Mono APs you can't deny.

With giant blocks and recursive tracks

I Like Big Blocks! (Final Chorus)

I like big blocks and I cannot lie!

Mono APs you can't deny.

With giant blocks and recursive tracks

Van der Waerden's got your back.

I Like Big Blocks! (Final Chorus)

I like big blocks and I cannot lie!

Mono APs you can't deny.

With giant blocks and recursive tracks

Van der Waerden's got your back.
(Applause if deserved.)

How Much Time?

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BILL Longer than it took to do admissions for REU-CAAR.

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