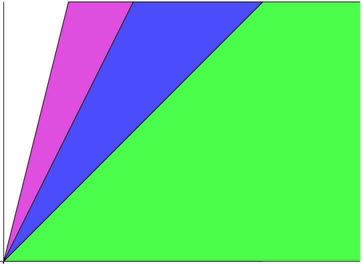
Plastic explosives:
A C_4 analog of the Kervaire invariant calculation

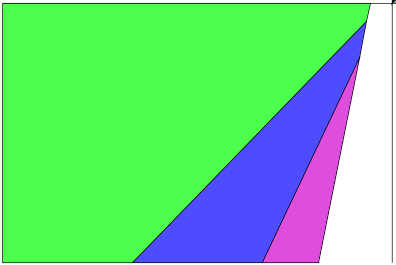
Conference on Equivariant, Chromatic and Motivic Homotopy Theory

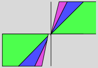
Northwestern University

March 25, 2013



Mike Hill
University of Virginia
Mike Hopkins
Harvard University
Doug Ravenel
University of Rochester





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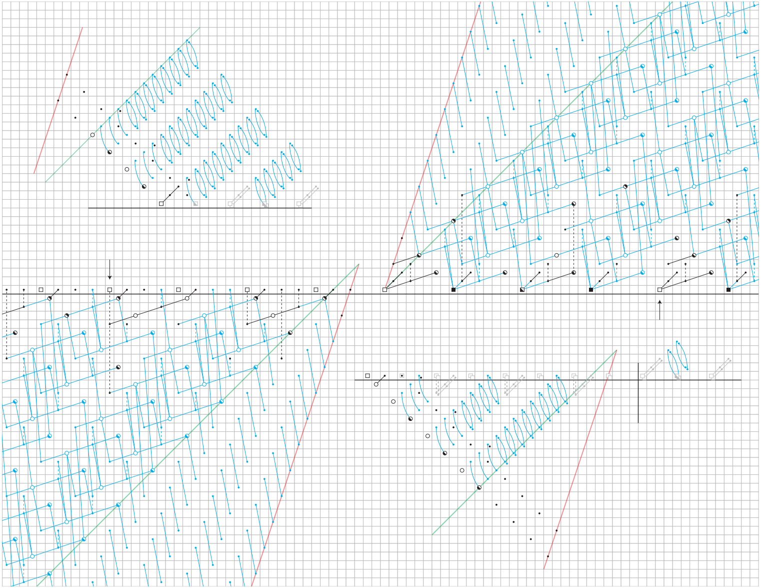
The Hopkins poster of 2008



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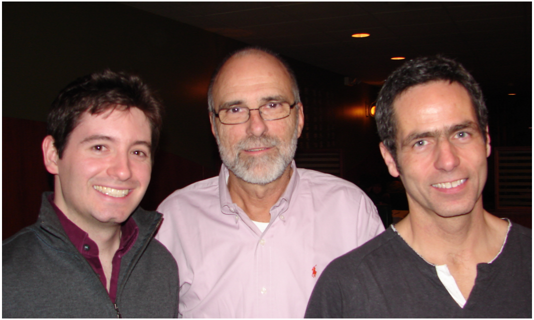

Mike Hill, myself and Mike Hopkins.
Photo by Bill Browder, 2010.

In 2009 Mike Hill, Mike Hopkins and I proved the following.

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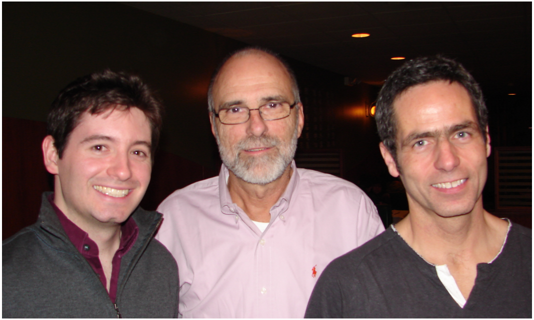

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The element $\theta_j \in \pi_{2^{j+1}-2}S^0$ associated with the Kervaire invariant does not exist for $j \geq 7$.

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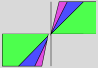

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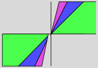

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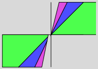
(ii) Periodicity Theorem $\Sigma^{256}\Omega \simeq \Omega$, so $\pi_k\Omega$ depends only on the value of k modulo 256.



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The second two of these imply that $\pi_{2^{j+1}-2}\Omega = 0$ for $j \geq 7$, so (i) implies that θ_j does not exist for such j.

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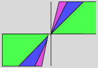
What this talk is about (continued)

The construction and study of the spectrum Ω involves equivariant stable homotopy theory.



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The construction and study of the spectrum Ω involves equivariant stable homotopy theory. The group G is question will always be a finite cyclic 2-group.

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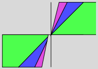

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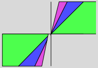

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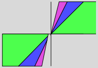

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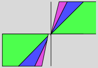

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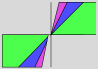
The complex cobordism spectrum MU has a C_2-action defined in terms of complex conjugation.



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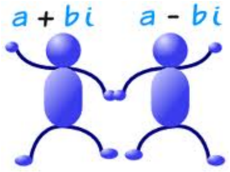

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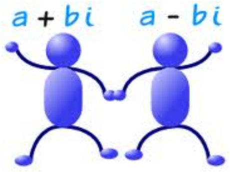

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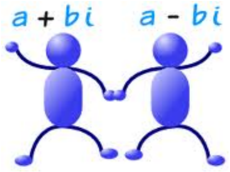

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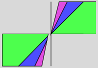

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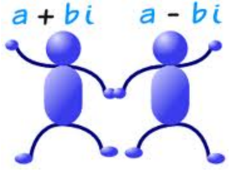

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1930–2005

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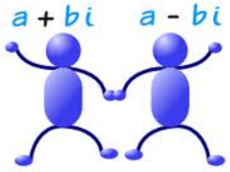

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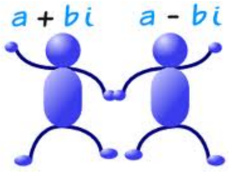

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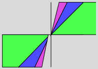
For any C_2-spectrum X, there is a C_8-action defined on its 4-fold smash power $X^{(4)}$.



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What this talk is about (continued)

For any C_2-spectrum X, there is a C_8-action defined on its 4-fold smash power $X^{(4)}$. This C_8-spectrum is denoted by $N_2^8 X$,

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For any C_2-spectrum X, there is a C_8-action defined on its 4-fold smash power $X^{(4)}$. This C_8-spectrum is denoted by $N_2^8 X$, the norm N_2^8 being a functor from C_2-spectra to C_8-spectra.

Mike Hill
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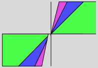

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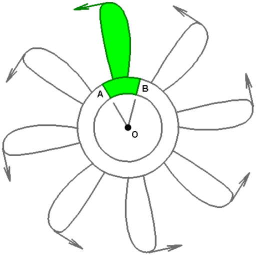

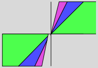

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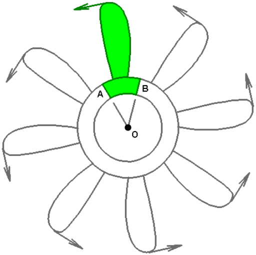
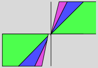


Inverting a certain element $D \in \pi_*^{C_8} N_2^8 MU_{\mathbf{R}}$ gives a 256-periodic C_8-spectrum $\widetilde{\Omega} = D^{-1} N_2^8 MU_{\mathbf{R}}$.



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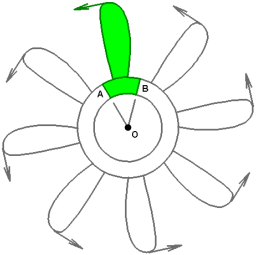

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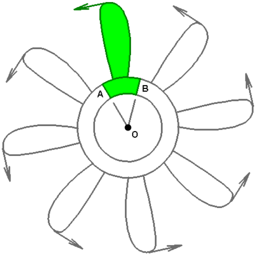

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$$\Omega = \widetilde{\Omega}^{C_8}.$$

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What this talk is about (continued)

We developed a new tool for studying such spectra called the slice spectral sequence.

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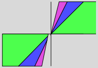

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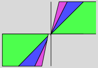

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We developed a new tool for studying such spectra called the slice spectral sequence. I will say more about it later. It is indispensable for proving the Gap Theorem.

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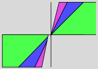

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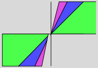
The homotopy groups of $\widetilde{\Omega}$ and Ω are inaccessibly complicated,



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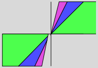

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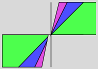
Analogous constructions with C_8 replaced by C_2 or C_4 are not so bad.



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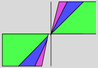
Analogous constructions with C_8 replaced by C_2 or C_4 are not so bad. This talk is about those cases.



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The C_2 case

In the C_2 case we start with $MU_{\mathbf{R}}$ itself,

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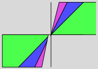
In the C_2 case we start with $MU_{\mathbf{R}}$ itself, invert a 2-dimensional generator in its equivariant homotopy,



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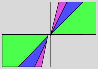
In the C_2 case we start with $MU_{\mathbf{R}}$ itself, invert a 2-dimensional generator in its equivariant homotopy, and throw out some redundant higher dimensional generators.



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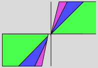
Sir Michael Atiyah

It was originally studied by Atiyah in 1966 in a paper called *K-theory and reality*.



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The C_2 case (continued)

The slice spectral sequence for $K_{\mathbf{R}}$ was the subject of Dan Dugger's thesis.

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The C_2 case (continued)

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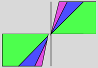

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The C_2 case (continued)

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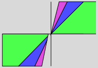

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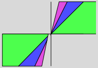
The slice spectral sequence

The slice spectral sequence is an equivariant analog of the Postnikov filtration.



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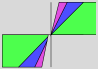
The slice spectral sequence is an equivariant analog of the Postnikov filtration. In the latter we filter a spectrum X by its $(n-1)$-connected covers $\{P_n X\}$.



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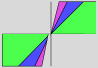
The slice spectral sequence

The slice spectral sequence is an equivariant analog of the Postnikov filtration. In the latter we filter a spectrum X by its $(n-1)$-connected covers $\{P_n X\}$. The cofiber of the map $P_{n+1}X \to X$ is the spectrum obtained from X by killing all homotopy groups above dimension n. It is the *nth Postnikov section of X*, denoted by $P^n X$.



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This collection of cofiber sequences leads to what might be called the Postnikov spectral sequence.

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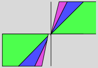

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The slice spectral sequence (continued)

Nevertheless, note that $P_n\mathcal{S}$, the category of $(n-1)$-connected spectra,

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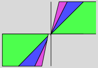

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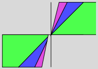

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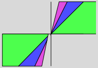

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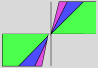

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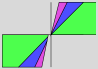

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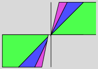

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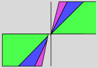

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We will call these spectra slice spheres.

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The slice spectral sequence for $G = C_2$ (continued)

For $G = C_2$ the generalization of

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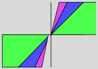

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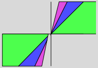

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Let $\mathcal{S}^G$ denote the category of G-spectra.

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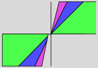

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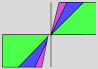
Let $\mathcal{S}^G$ denote the category of G-spectra. Define $P_n\mathcal{S}^G$ to be the subcategory generated by the elements of T_n^G,



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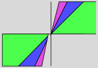
Let $\mathcal{S}^G$ denote the category of G-spectra. Define $P_n\mathcal{S}^G$ to be the subcategory generated by the elements of T_n^G, i.e., by slice spheres of dimension $\geq n$.



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The slice spectral sequence for $G = C_2$ (continued)

For $G = C_2$ the generalization of

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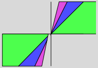
This filtration of $\mathcal{S}^G$ leads to the slice spectral sequence. It maps to the classical one under the forgetful functor $\mathcal{S}^G \to \mathcal{S}$. For a G-spectrum X it enables us to define G-analogs of connective covers. The nth slice $P_n^n X$ is the cofiber of the map $P_{n+1}X \to P_nX$ just as in the classical case.



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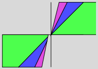
The slice spectral sequence for general groups G

The slice spectral sequence is more interesting than the Postnikov spectral sequence for the following reason.



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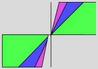

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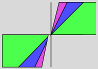

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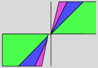

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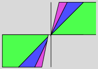

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$$T_n^G = \left\{ G_+ \underset{H}{\wedge} S^{m\rho_H - \epsilon} \colon m|H| - \epsilon \geq n,\ H \subset G,\ \epsilon = 0, 1 \right\},$$

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the set of slice spheres of dimension $\geq n$.

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The slice spectral sequence for general groups G (continued)

We use the resulting filtration of $\mathcal{S}^G$ to define

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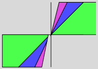

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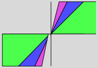
We use the resulting filtration of $\mathcal{S}^G$ to define "connective covers" $P_n X$,



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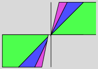
The slice spectral sequence for general groups G (continued)

We use the resulting filtration of $\mathcal{S}^G$ to define “connective covers” $P_n X$, “Postnikov sections” $P^n X$



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The slice spectral sequence for general groups G (continued)

We use the resulting filtration of $\mathcal{S}^G$ to define “connective covers” P_nX, “Postnikov sections” P^nX and slices P_n^nX as before.

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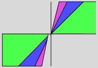
We use the resulting filtration of $\mathcal{S}^G$ to define “connective covers” $P_n X$, “Postnikov sections” $P^n X$ and slices $P_n^n X$ as before.

Determining the slices of a G-spectrum X is not easy in general.



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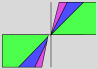
The slice spectral sequence for general groups G (continued)

We use the resulting filtration of $\mathcal{S}^G$ to define "connective covers" P_nX, "Postnikov sections" P^nX and slices P_n^nX as before.

Determining the slices of a G-spectrum X is not easy in general. The main technical computation of HHR is the identification of these slices for the spectra of interest in the paper.



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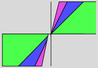

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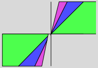
$$P_n^nX = W_n \wedge H\underline{\mathbf{Z}},$$



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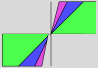
$$P_n^nX = W_n \wedge H\underline{\mathbf{Z}},$$

where W_n is a wedge of n-dimensional slice spheres



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The slice spectral sequence for general groups G (continued)

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Mike Hill
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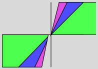

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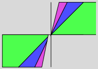

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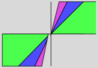

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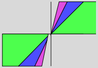

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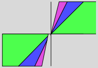

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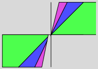

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God help us!

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What is a Mackey functor?

Fix a group G.

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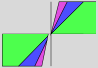

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What is a Mackey functor?

Fix a group G. Assume for simplicity that it is finite and abelian.

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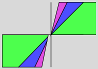
Fix a group G. Assume for simplicity that it is finite and abelian. The examples of interest to us are finite cyclic 2-groups.



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What is a Mackey functor?

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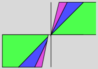
Formally a Mackey functor $\underline{M}$ assigns an abelian group to every finite G-set and is additive on disjoint unions,



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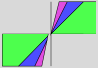

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$$K \subset H \subset G$$

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$$\begin{tikzcd} \underline{M}(G/H) \arrow[d, bend right, "\mathrm{Res}_K^H"'] \\ \underline{M}(G/K), \arrow[u, bend right, "\mathrm{Tr}_K^H"'] \end{tikzcd}$$

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called restrictions and transfers, with certain properties.

Plastic explosives

Mike Hill
Mike Hopkins
Doug Ravenel

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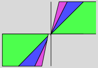
Rather than spell out these properties, we give two instructive examples.



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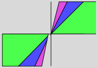

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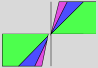

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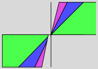
is obvious:



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$$Res_K^H(Tr_K^H(x)) = \sum_{\gamma \in H/K} \gamma(x) \in \underline{M}(G/K).$$

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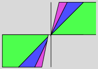

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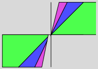
Note that the sum on the right is fixed by H, so it is in the image of the monomorphism Res_K^H. Thus $Tr_K^H(x) \in \underline{M}(G/H)$ is determined by its image in $\underline{M}(G/K)$.



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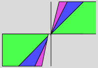

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that induces the desired map of ordinary homotopy groups.

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The category of Mackey functors

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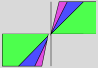

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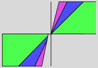

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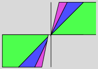
Mike Hopkins
Doug Ravenel



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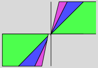

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Consider this a homework problem.

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The category of Mackey functors (continued)

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We will denote Mackey functors $\underline{M}$ for $G = C_2$ and $G = C_4$ by diagrams

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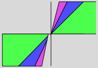

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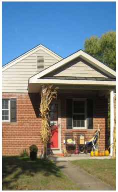

$$\begin{tikzcd} \underline{M}(G/G) \arrow[d, bend right, "\mathrm{Res}_1^2"'] \\ \underline{M}(G/e) \arrow[u, bend right, "\mathrm{Tr}_1^2"'] \end{tikzcd}$$

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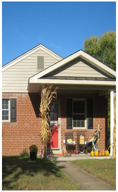

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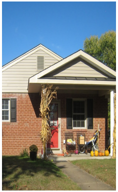

$$\begin{tikzcd} \underline{M}(G/G) \arrow[d, bend right, "\mathrm{Res}_1^2"'] \\ \underline{M}(G/e) \arrow[u, bend right, "\mathrm{Tr}_1^2"'] \end{tikzcd} \quad \text{and} \quad \begin{tikzcd} \underline{M}(G/G) \arrow[d, bend right, "\mathrm{Res}_2^4"'] \\ \underline{M}(G/C_2) \arrow[u, bend right, "\mathrm{Tr}_2^4"'] \arrow[d, bend right, "\mathrm{Res}_1^2"'] \\ \underline{M}(G/e) \arrow[u, bend right, "\mathrm{Tr}_1^2"'] \end{tikzcd}$$

and later abbreviate certain ones by hieroglyphic symbols.

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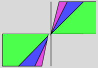

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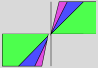

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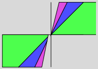

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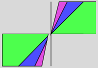

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G-CW spectra (continued)

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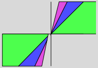

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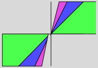

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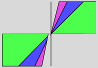

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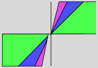

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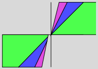

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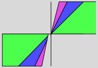

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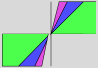

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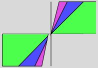

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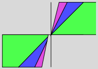
Slices again

Recall that for the G-spectra we are interested in,

Mike Hill
Mike Hopkins
Doug Ravenel



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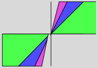

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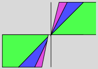
$$H_*(\underline{C}_* W) = \underline{\pi}_* W \wedge H\underline{\mathbf{Z}},$$



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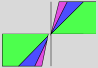

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$$C_i W = \begin{cases} \\ \\ \end{cases}$$

Plastic explosives

Mike Hill
Mike Hopkins
Doug Ravenel

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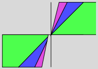
and it is easy to work out the graded Mackey functor $H_*(\underline{C}_* W)$.



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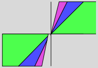

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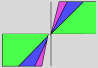

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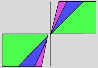

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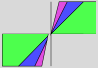

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We also know that its $2m$th slice is $S^{m\rho} \wedge H\underline{\mathbf{Z}}$ for each integer m. The oddly indexed slices are contractible. This enables us to compute the $\underline{E}_2$-term of the slice spectral sequence converging to $\underline{\pi}_* K_{\mathbf{R}}$.

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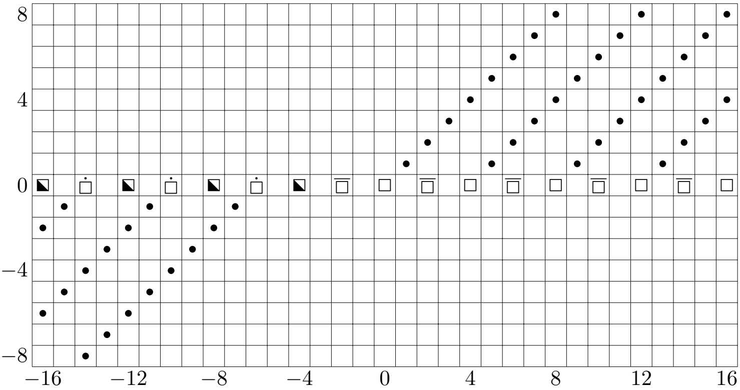

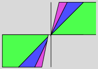

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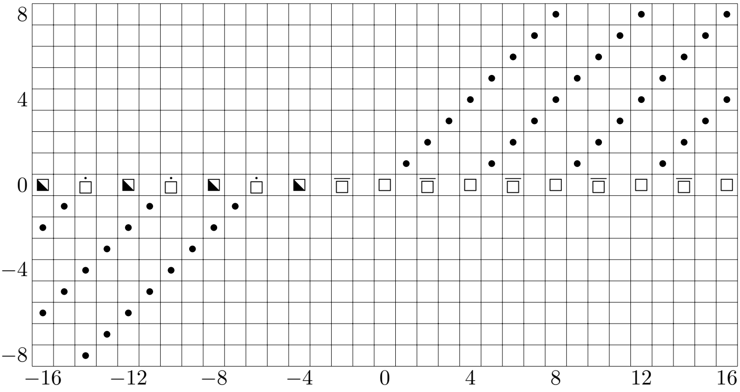

$$\boxslash \hookrightarrow \square \twoheadrightarrow \bullet \qquad\qquad \underline{M} \qquad\qquad \bullet \hookrightarrow \dot{\square} \twoheadrightarrow \overline{\square}$$

$$\begin{tikzcd}
\mathbf{Z} \arrow[r, "2"] \arrow[d, shift right, "2"'] & \mathbf{Z} \arrow[r, "1"] \arrow[d, shift right, "1"'] & \mathbf{Z}/2 \arrow[d, shift right] \\
\mathbf{Z} \arrow[r, "1"] \arrow[u, shift right, "1"'] & \mathbf{Z} \arrow[r] \arrow[u, shift right, "2"'] \arrow[d, equal] & 0 \arrow[u, shift right] \\
& \mathbf{Z}C_2/(1-\gamma) &
\end{tikzcd}
\qquad
\begin{tikzcd}
\underline{M}(C_2/C_2) \arrow[d, shift right, "\mathrm{Res}_1^2"'] \\
\underline{M}(C_2/e) \arrow[u, shift right, "\mathrm{Tr}_1^2"']
\end{tikzcd}
\qquad
\begin{tikzcd}
\mathbf{Z}/2 \arrow[r, "1"] \arrow[d, shift right] & \mathbf{Z}/2 \arrow[r] \arrow[d, shift right, "0"'] & 0 \arrow[d, shift right] \\
0 \arrow[r] \arrow[u, shift right] & \mathbf{Z}_- \arrow[r, "1"] \arrow[u, shift right, "1"'] \arrow[d, equal] & \mathbf{Z}_- \arrow[u, shift right] \\
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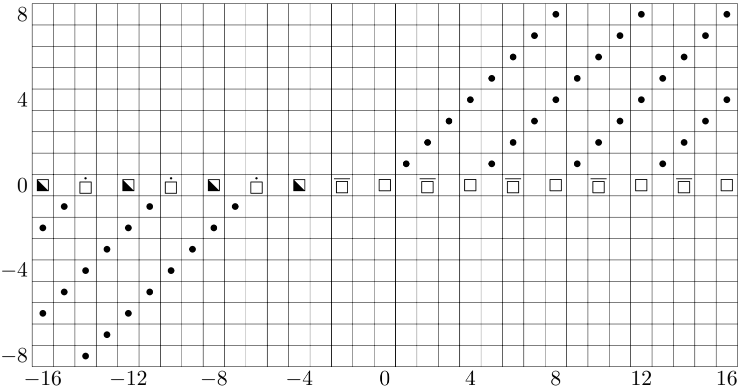

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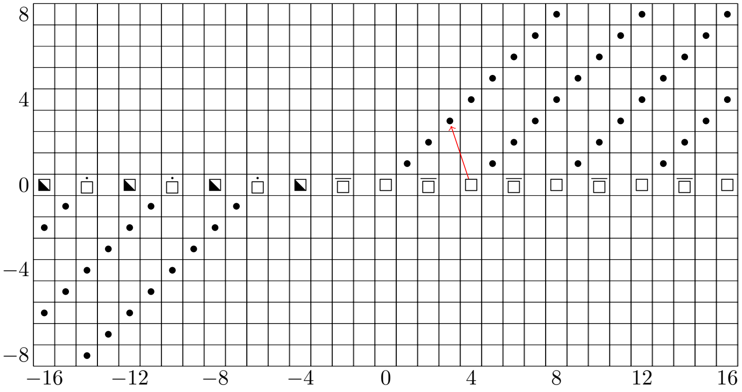

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$$\begin{array}{ccccc} \mathbf{Z} & \xrightarrow{2} & \mathbf{Z} & \xrightarrow{1} & \mathbf{Z}/2 \\ {\scriptstyle 2}\downarrow\uparrow{\scriptstyle 1} & & {\scriptstyle 1}\downarrow\uparrow{\scriptstyle 2} & & \downarrow\uparrow \\ \mathbf{Z} & \xrightarrow{1} & \mathbf{Z} & \longrightarrow & 0 \\ & & \| & & \\ & & \mathbf{Z}C_2/(1-\gamma) & & \end{array} \qquad \begin{array}{c} \underline{M}(C_2/C_2) \\ \mathrm{Res}_1^2\downarrow\uparrow\mathrm{Tr}_1^2 \\ \underline{M}(C_2/e) \end{array} \qquad \begin{array}{ccccc} \mathbf{Z}/2 & \xrightarrow{1} & \mathbf{Z}/2 & \longrightarrow & 0 \\ \downarrow\uparrow & & {\scriptstyle 0}\downarrow\uparrow{\scriptstyle 1} & & \downarrow\uparrow \\ 0 & \longrightarrow & \mathbf{Z}_- & \xrightarrow{1} & \mathbf{Z}_- \\ & & \| & & \\ & & \mathbf{Z}C_2/(1+\gamma) & & \end{array}$$

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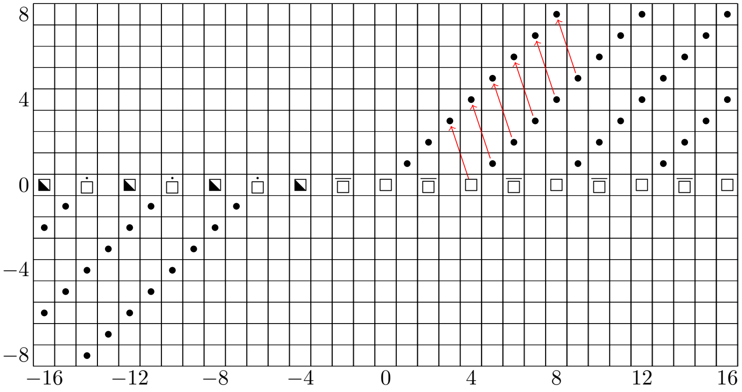

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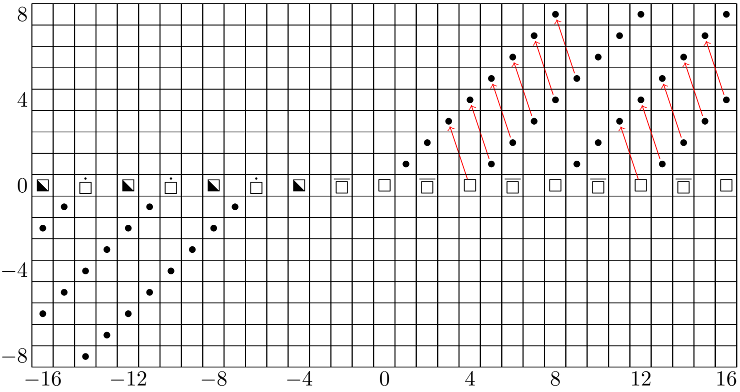

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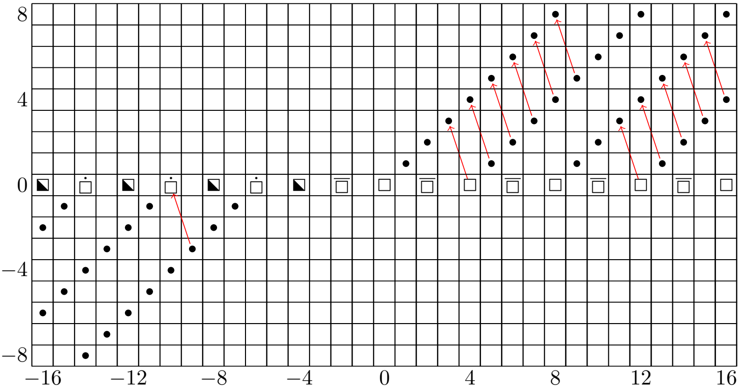

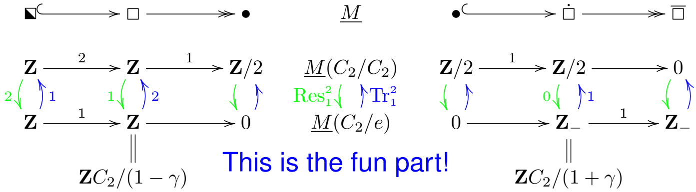

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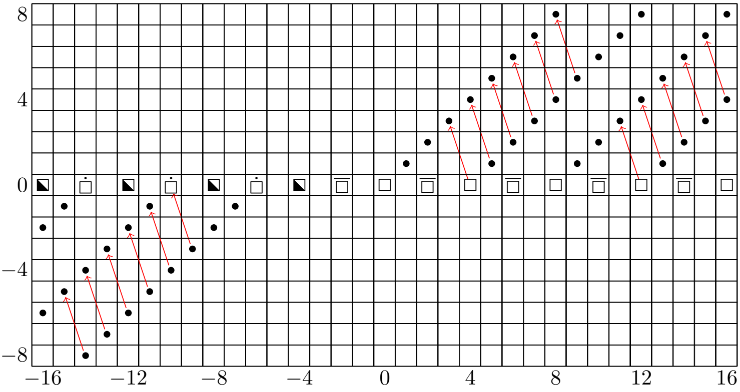

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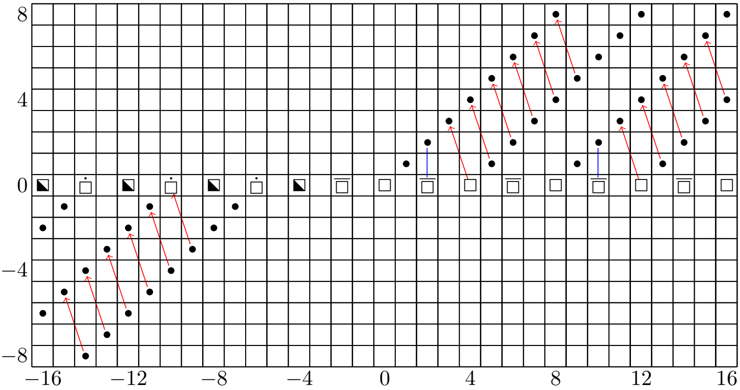

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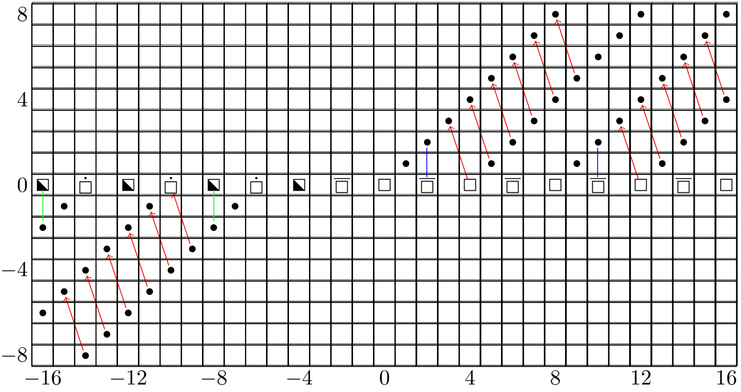

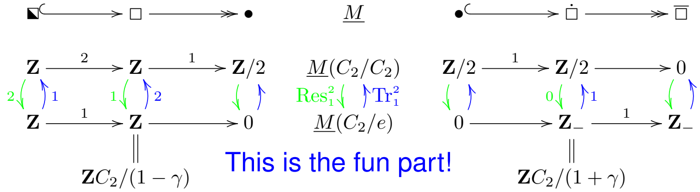

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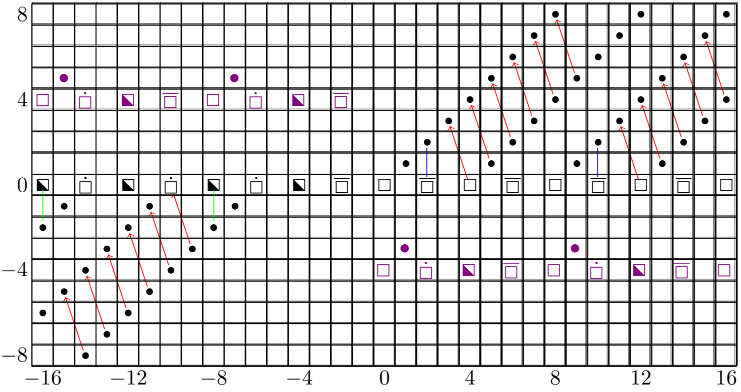

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We start with the C_4-spectrum $N_2^4 MU_{\mathbf{R}}$.

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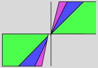

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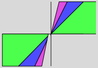
The action of a generator $\gamma \in G = C_4$ is



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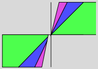
$$\gamma(x_i) = y_i \qquad \text{and} \qquad \gamma(y_i) = (-1)^i x_i.$$

Then we invert

$$D = (x_1 y_1)^2 \left(-5(x_1^4 + y_1^4) + 19(x_1 y_1)^2 + 20 x_1 y_1 (x_1^2 - y_1^2)\right)$$



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and kill suitably chosen x_i and y_i for $i > 1$. We denote the resulting C_4-spectrum by $K_{\mathbf{H}}$.

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The C_4 case

We start with the C_4-spectrum $N_2^4 MU_{\mathbf{R}}$. Its underlying homotopy is

$$\pi_*^u N_2^4 MU_{\mathbf{R}} = \pi_* MU \wedge MU = \mathbf{Z}[x_i, y_i : i > 0] \quad \text{where } x_i, y_i \in \pi_{2i}$$

The action of a generator $\gamma \in G = C_4$ is

$$\gamma(x_i) = y_i \qquad \text{and} \qquad \gamma(y_i) = (-1)^i x_i.$$

Then we invert

$$D = (x_1 y_1)^2 \left(-5(x_1^4 + y_1^4) + 19(x_1 y_1)^2 + 20 x_1 y_1 (x_1^2 - y_1^2)\right)$$

and kill suitably chosen x_i and y_i for $i > 1$. We denote the resulting C_4-spectrum by $K_{\mathbf{H}}$. It is 32-periodic.

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and kill suitably chosen x_i and y_i for $i > 1$. We denote the resulting C_4-spectrum by $K_{\mathbf{H}}$. It is 32-periodic. It has a connective version $k_{\mathbf{H}}$ that we get without inverting D.

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Relation to *TMF*

The C_4-spectrum $K_{\mathbf{H}}$ is known to be equivalent to $TMF_1(5)$,

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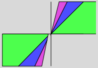

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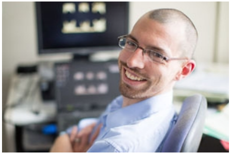

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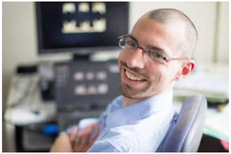

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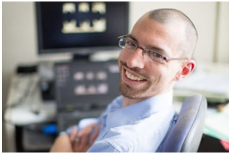

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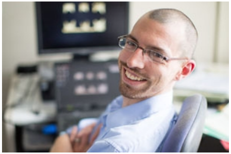
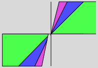


It is defined as follows. The spectrum *TMF* is derived from the moduli stack of elliptic curves $\mathcal{M}$. Roughly speaking a point on $\mathcal{M}$ corresponds to an elliptic curve C.



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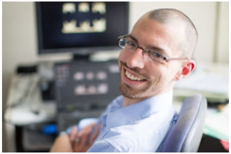

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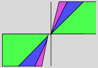
One can consider the moduli stack of $\mathcal{M}_1(5)$ for which each point is an elliptic curve C equipped with a point P of order 5.



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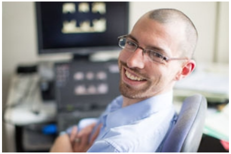

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One can consider the moduli stack of $\mathcal{M}_1(5)$ for which each point is an elliptic curve C equipped with a point P of order 5. The group $C_4 = (\mathbf{Z}/5)^\times$ acts on it by sending each P to appropriate powers.

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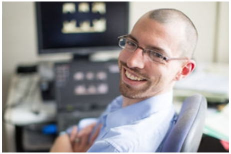

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One can consider the moduli stack of $\mathcal{M}_1(5)$ for which each point is an elliptic curve C equipped with a point P of order 5. The group $C_4 = (\mathbf{Z}/5)^\times$ acts on it by sending each P to appropriate powers. The orbit stack $\mathcal{M}_0(5)$ classifies elliptic curves equipped with subgroups of order 5.

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Relation to *TMF* (continued)

There are corresponding spectra $TMF_1(5)$ and $TMF_0(5)$.

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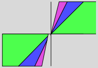

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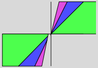
Relation to *TMF* (continued)

There are corresponding spectra $TMF_1(5)$ and $TMF_0(5)$. The forgetful maps of stacks

$$\begin{array}{ccccc} \mathcal{M}_1(5) & \longrightarrow & \mathcal{M}_0(5) & \longrightarrow & \mathcal{M} \\ & & \| & & \\ & & \mathcal{M}_1(5)/C_4 & & \end{array}$$



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Relation to *TMF* (continued)

There are corresponding spectra $TMF_1(5)$ and $TMF_0(5)$. The forgetful maps of stacks

$$\begin{tikzcd} \mathcal{M}_1(5) \arrow[r] & \mathcal{M}_0(5) \arrow[r] \arrow[d, equal] & \mathcal{M} \\ & \mathcal{M}_1(5)/C_4 & \end{tikzcd}$$

lead to maps of spectra

$$\begin{tikzcd} TMF_1(5) & TMF_0(5) \arrow[l] \arrow[d, equal] & TMF \arrow[l] \\ & TMF_1(5)^{C_4} & \end{tikzcd}$$

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The C_4-spectrum $TMF_1(5)$ is equivariantly equivalent to our $K_{\mathbf{H}}$.

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The C_4-spectrum $TMF_1(5)$ is equivariantly equivalent to our $K_{\mathbf{H}}$. This makes the fixed point spectrum $K_{\mathbf{H}}^{C_4}$ a TMF-module.

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Relation to *TMF* (continued)

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The C_4-spectrum $TMF_1(5)$ is equivariantly equivalent to our $K_{\mathbf{H}}$. This makes the fixed point spectrum $K_{\mathbf{H}}^{C_4}$ a *TMF*-module. This is helpful for understanding its homotopy.

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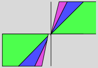
Back to $K_{\mathbf{H}}$ and $k_{\mathbf{H}}$

Let $G = C_4$ and $G \supset G' = C_2$.



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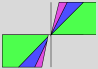
Back to $K_{\mathbf{H}}$ and $k_{\mathbf{H}}$

Let $G = C_4$ and $G \supset G' = C_2$. Denote their regular representations by ρ_4 and ρ_2.



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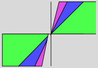
Back to $K_{\mathbf{H}}$ and $k_{\mathbf{H}}$

Let $G = C_4$ and $G \supset G' = C_2$. Denote their regular representations by ρ_4 and ρ_2.

To describe the slices of $k_{\mathbf{H}}$ and $K_{\mathbf{H}}$, let

$$W_{m,n} = \begin{cases} S^{m\rho_4} & \text{for } m = n \\ G_+ \underset{G'}{\wedge} S^{(m+n)\rho_2} & \text{for } m < n. \end{cases}$$



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Then we have

$$P_n^n k_{\mathbf{H}} = \begin{cases} \left(\bigvee_{0 \le m \le n/4} W_{m,n/2-m}\right) \wedge H\underline{\mathbf{Z}} & \text{for } n \text{ even and } n \ge 0 \\ * & \text{otherwise} \end{cases}$$

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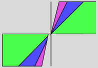

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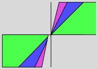
$$P_n^n K_{\mathbf{H}} = \begin{cases} \left(\bigvee_{m \le n/4} W_{m,n/2-m} \right) \wedge H\underline{\mathbf{Z}} & \text{for } n \text{ even} \\ * & \text{otherwise.} \end{cases}$$

The latter slices have infinitely many summands.



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The C_4 case (continued)

These slices are uncomfortably large.

Mike Hill
Mike Hopkins
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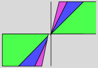

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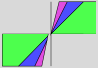
Fortunately there is a remedy.



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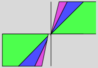
Fortunately there is a remedy. Consider $k_{\mathbf{H}}$ as a C_2-spectrum via the forgetful functor.



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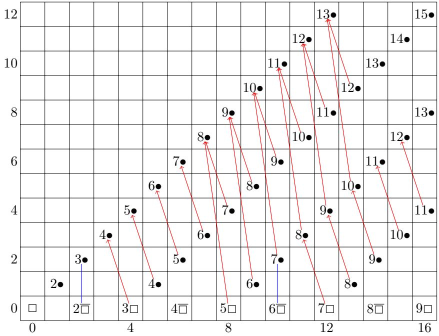

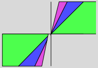

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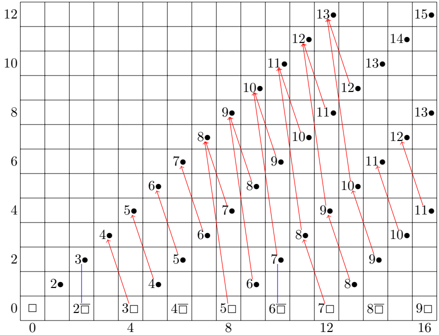

The differentials and exotic transfers above have maximal rank.

Plastic explosives

Mike Hill
Mike Hopkins
Doug Ravenel

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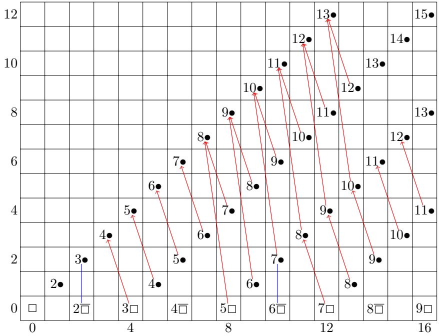

The differentials and exotic transfers above have maximal rank. This pattern is easy to understand.

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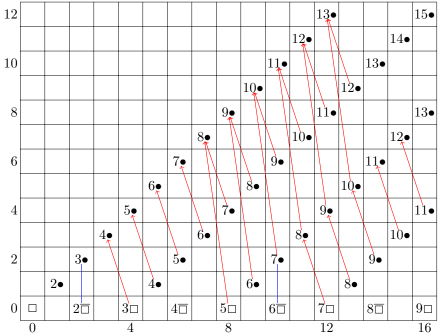

The differentials and exotic transfers above have maximal rank. This pattern is easy to understand. There is a way to remove most of these elements and their transfers from the picture.

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The reduced $\underline{E}_4$-term

Here is the resulting reduced $\underline{E}_4$-term for $k_{\mathbf{H}}$.

Mike Hill
Mike Hopkins
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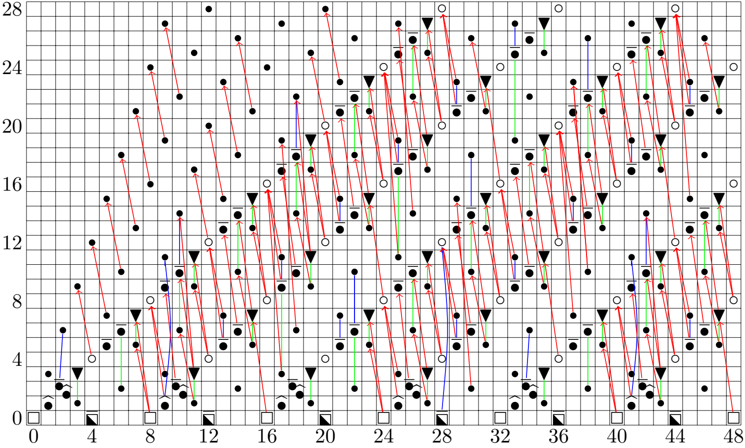

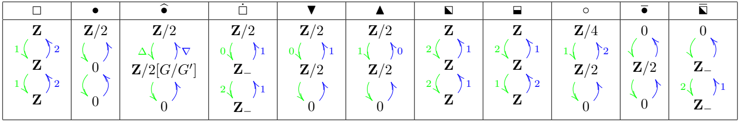

Plastic explosives

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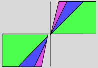

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And here it is for $K_{\mathbf{H}}$.

Mike Hill
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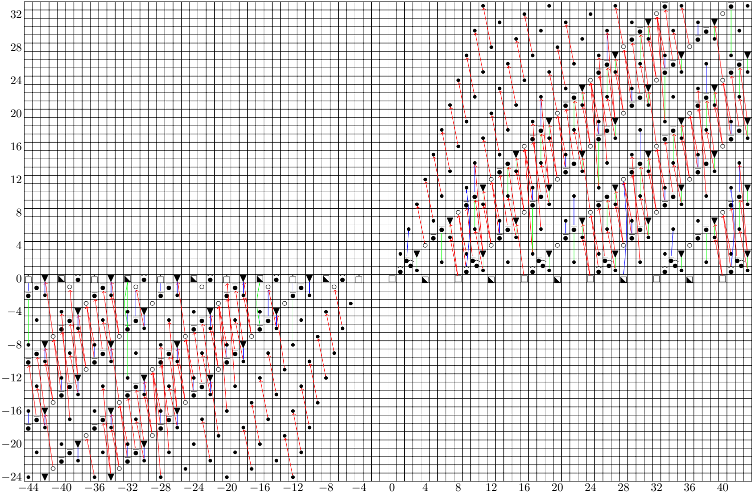

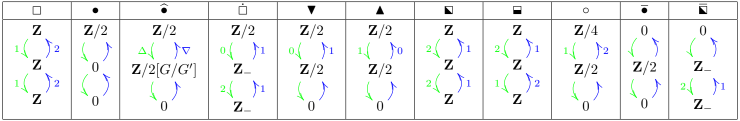

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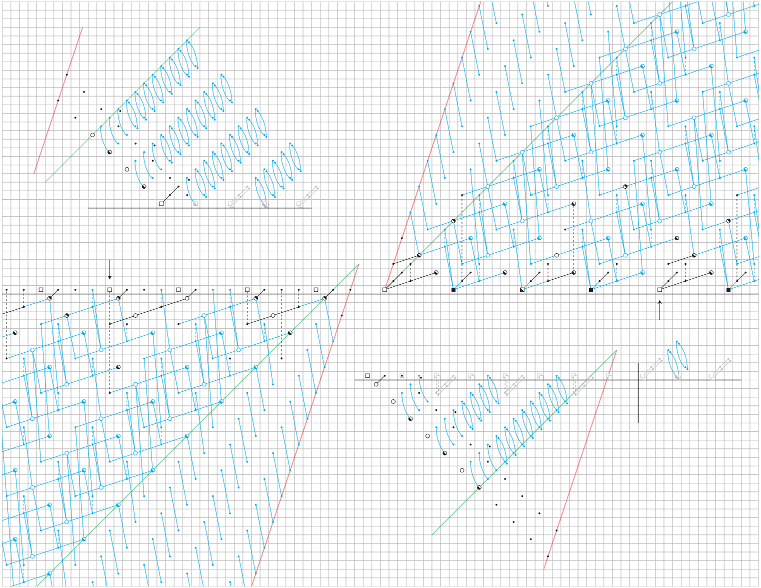
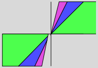
The Hopkins poster again





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$\Box$	$\bullet$	$\widehat{\bullet}$	$\dot{\Box}$	$\blacktriangledown$	$\blacktriangle$	◪	⬓	$\circ$	$\overline{\bullet}$	$\overline{◪}$
$\mathbf{Z}$ $1\downarrow\ \uparrow 2$ $\mathbf{Z}$ $1\downarrow\ \uparrow 2$ $\mathbf{Z}$	$\mathbf{Z}/2$ $\downarrow\ \uparrow$ 0 $\downarrow\ \uparrow$ 0	$\mathbf{Z}/2$ $\Delta\downarrow\ \uparrow\nabla$ $\mathbf{Z}/2[G/G']$ $\downarrow\ \uparrow$ 0	$\mathbf{Z}/2$ $0\downarrow\ \uparrow 1$ $\mathbf{Z}_-$ $2\downarrow\ \uparrow 1$ $\mathbf{Z}_-$	$\mathbf{Z}/2$ $0\downarrow\ \uparrow 1$ $\mathbf{Z}/2$ $\downarrow\ \uparrow$ 0	$\mathbf{Z}/2$ $1\downarrow\ \uparrow 0$ $\mathbf{Z}/2$ $\downarrow\ \uparrow$ 0	$\mathbf{Z}$ $2\downarrow\ \uparrow 1$ $\mathbf{Z}$ $2\downarrow\ \uparrow 1$ $\mathbf{Z}$	$\mathbf{Z}$ $2\downarrow\ \uparrow 1$ $\mathbf{Z}$ $1\downarrow\ \uparrow 2$ $\mathbf{Z}$	$\mathbf{Z}/4$ $1\downarrow\ \uparrow 2$ $\mathbf{Z}/2$ $\downarrow\ \uparrow$ 0	0 $\downarrow\ \uparrow$ $\mathbf{Z}/2$ $\downarrow\ \uparrow$ 0	0 $\downarrow\ \uparrow$ $\mathbf{Z}_-$ $2\downarrow\ \uparrow 1$ $\mathbf{Z}_-$

This is the resulting $\underline{E}_{14} = \underline{E}_\infty$-term.

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$\square$	$\bullet$	$\widehat{\bullet}$	$\dot{\square}$	$\blacktriangledown$	$\blacktriangle$	$\boxslash$	$\boxminus$	$\circ$	$\overline{\bullet}$	$\overline{\boxslash}$
$\mathbf{Z}$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}$	$\mathbf{Z}$	$\mathbf{Z}/4$	0	0
$1 \quad 2$		$\triangle \quad \triangledown$	$0 \quad 1$	$0 \quad 1$	$1 \quad 0$	$2 \quad 1$	$2 \quad 1$	$1 \quad 2$		
$\mathbf{Z}$	0	$\mathbf{Z}/2[G/G']$	$\mathbf{Z}_-$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}$	$\mathbf{Z}$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}_-$
$1 \quad 2$			$2 \quad 1$			$2 \quad 1$	$1 \quad 2$			$2 \quad 1$
$\mathbf{Z}$	0	0	$\mathbf{Z}_-$	0	0	$\mathbf{Z}$	$\mathbf{Z}$	0	0	$\mathbf{Z}_-$

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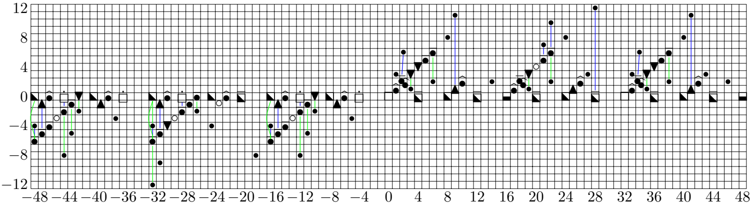

Plastic explosives

Mike Hill
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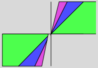

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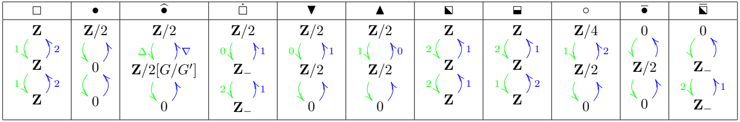

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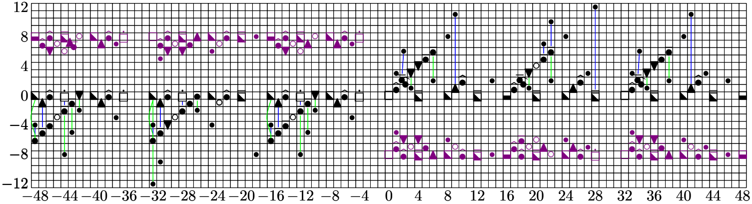

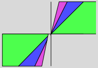

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□	•	$\widehat{\bullet}$	$\dot{\square}$	▼	▲	◪	⬓	○	$\overline{\bullet}$	$\overline{◪}$
$\mathbf{Z}$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}/2$	$\mathbf{Z}$	$\mathbf{Z}$	$\mathbf{Z}/4$	0	0
$1 \quad 2$		$\Delta \quad \nabla$	$0 \quad 1$	$0 \quad 1$	$1 \quad 0$	$2 \quad 1$	$2 \quad 1$	$1 \quad 2$		
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$1 \quad 2$			$2 \quad 1$			$2 \quad 1$	$1 \quad 2$			$2 \quad 1$
$\mathbf{Z}$	0	0	$\mathbf{Z}_-$	0	0	$\mathbf{Z}$	$\mathbf{Z}$	0	0	$\mathbf{Z}_-$

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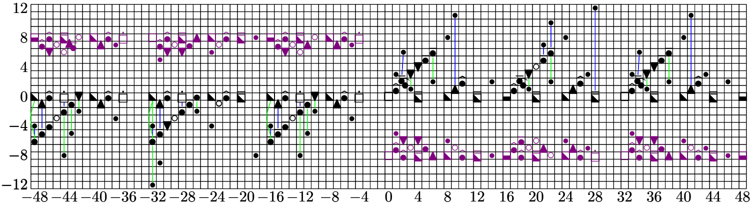

The exotic Mackey functor extensions in the first and third quadrants

Mike Hill
Mike Hopkins
Doug Ravenel

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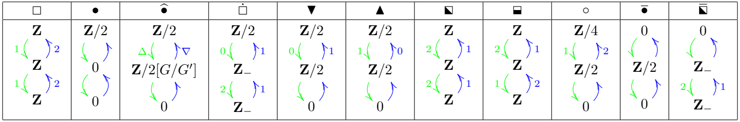

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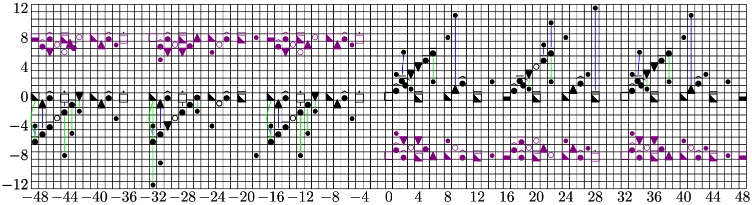

The exotic Mackey functor extensions in the first and third quadrants lead to the Mackey functors shown in violet in the second and fourth quadrants.

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