

INTRODUCTION TO W -GRAPHS

1. KAZHDAN–LUSZTIG W -GRAPHS

Recall that, in [KL79], Kazhdan and Lusztig found a pair of self-dual bases over $\mathcal{H}(W, S)$ in terms of the standard basis $\{T_x : x \in W\}$. These are the *Kazhdan–Lusztig* (or *canonical*) basis

$$C_x = (-1)^{\ell(x)} q^{\frac{1}{2}\ell(x)} \sum_{y \leq x} (-1)^{\ell(y)} q^{-\ell(y)} \overline{P_{y,x}(q)} T_y$$

and the *dual Kazhdan–Lusztig* (or *dual canonical*) basis

$$C'_x = q^{-\frac{1}{2}\ell(x)} \sum_{y \leq x} P_{y,x}(q) T_y.$$

Let $\mathcal{D}_x := \{s \in S : sx < x\}$ denote the (left) descent set of x . It was also shown in [KL79] that

$$T_s C_x = \begin{cases} -C_x, & \text{if } s \in \mathcal{D}_x; \\ qC_x + q^{1/2} \sum_{\{y \in W : s \in \mathcal{D}_y\}} \mu(y, x)y, & \text{otherwise} \end{cases}$$

and

$$T_s C'_x = \begin{cases} qC_x, & \text{if } s \in \mathcal{D}_x; \\ -C_x + q^{1/2} \sum_{\{y \in W : s \in \mathcal{D}_y\}} \mu(y, x)y, & \text{otherwise.} \end{cases}$$

Is this true? Why are we missing the term $q^{1/2}C_{sx}$? This motivates the following definition.

Definition 1. (W -Graph). Let (W, S) be a Coxeter system and $\mathcal{H}(W, S)$ its associated Iwahori–Hecke algebra. A W -graph is a triple (X, I, μ) consisting of a set X of vertices, a function $I : X \rightarrow \mathcal{P}(S)$ that assigns to each vertex $x \in X$ a descent set $I_x \subseteq S$, and a function

$$\mu : X \times X \rightarrow \mathbb{Z}$$

such that the edge weight $\mu(y, x)$ is non-zero if and only if $y \rightarrow x$ is an edge of the graph. Moreover, if $E := \mathbb{Z}[q^{\pm 1/2}]X$ is the free $\mathbb{Z}[q^{\pm 1/2}]$ -module with basis X , we ask that the $\mathbb{Z}[q^{\pm 1/2}]$ -endomorphisms of E of the form

$$\tau_s(x) := \begin{cases} -x, & \text{if } s \in I_x; \\ qx + q^{1/2} \sum_{\{y \in X : s \in I_y\}} \mu(y, x)y, & \text{otherwise} \end{cases}$$

for each $s \in S$ satisfy the braid relations

$$\underbrace{\tau_s \tau_t \tau_s \cdots}_{m_{st} \text{ factors}} = \underbrace{\tau_t \tau_s \tau_t \cdots}_{m_{st} \text{ factors}},$$

for all $s, t \in S$ such that $m_{st} \neq \infty$. We define dual W -graphs similarly, where we instead use $\mathbb{Z}[q^{\pm 1/2}]$ -endomorphisms of E of the form

$$\tau'_s(x) := \begin{cases} qx, & \text{if } s \in I_x; \\ -x + q^{1/2} \sum_{\{y \in X : s \in I_y\}} \mu(y, x)y, & \text{otherwise.} \end{cases}$$

Asking that the A -endomorphisms τ_s defined above satisfy the braid relations is exactly equivalent to asking that E admit a $\mathcal{H}(W, S)$ -module structure given by $T_s \cdot x := \tau_s(x)$. This is because all $\mathbb{Z}[q^{\pm 1/2}]$ -endomorphisms of the form τ_s satisfy the quadratic relation $(\tau_s + 1)(\tau_s - q) = 0$, provided the sums are finite. To see that this is true, observe that when $s \notin I_x$, we have

$$\begin{aligned}
& (\tau_s + 1)(\tau_s - q)x \\
&= \tau_s^2(x) - q\tau_s(x) + \tau_s(x) - qx \\
&= q\tau_s(x) + q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)\tau_s(y) - q\tau_s(x) + qx + q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)y - qx \\
&= q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)\tau_s(y) + q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)y \\
&= q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)(-y) + q^{1/2} \sum_{\{y \in X: s \in I_y\}} \mu(y, x)y \\
&= 0.
\end{aligned}$$

Conversely, when $s \in I_x$, the result follows trivially. It follows that every W -graph (and dual W -graph) corresponds to a representation $\varphi : \mathcal{H}(W, S) \rightarrow \text{End}(E)$ given on the generators by $\varphi : T_s \mapsto \tau_s$.

It is sometimes convenient to look at the transposes of τ_s and τ'_s . In particular, suppose we fix $s \in S$ and choose an ordering $X = \{x_1, \dots, x_n\}$ such that $s \in I_{x_i}$ for all $1 \leq i \leq k$ and $s \notin I_{x_j}$ for all $j \geq k$. Then we can express τ_s and τ'_s as the matrices

$$\tau_s = \begin{pmatrix} -I_k & 0 \\ * & qI_{n-k} \end{pmatrix} \quad \text{and} \quad \tau'_s = \begin{pmatrix} qI_k & 0 \\ * & -I_{n-k} \end{pmatrix},$$

where I_k is the $k \times k$ identity matrix and the block labelled by the asterisk $*$ has elements that are either 0 or of the form $q^{1/2}\mu(y, x)$. The transposes of τ_s and τ'_s thus involve moving only the sums, giving us

$$\tau_s^T(x) = \begin{cases} -x + q^{1/2} \sum_{\{y \in X: s \notin I_y\}} \mu(y, x)y, & \text{if } s \in I_x; \\ qx, & \text{otherwise} \end{cases}$$

and

$$(\tau'_s)^T(x) = \begin{cases} qx + q^{1/2} \sum_{\{y \in X: s \notin I_y\}} \mu(y, x)y, & \text{if } s \in I_x; \\ -x, & \text{otherwise,} \end{cases}$$

respectively. These also produce representations of $\mathcal{H}(W, S)$, and hence W -graphs, of their own.

The (one-sided) W -graphs constructed in [KL79] are defined by taking

$$X := W, \quad I_x := \mathcal{D}_x \quad \text{and} \quad \mu(y, x) := c(y, x) + c(x, y),$$

where $c(y, x)$ is defined to be the coefficient of $q^{(\ell(x) - \ell(y) - 1)/2}$ (the power of q of maximal degree) in the Kazhdan–Lusztig polynomial $P_{y,x}(q)$. Note that either $c(y, x) = 0$ or $c(x, y) = 0$ (usually both), so these W -graphs are not directed. They correspond to the left regular representation of $\mathcal{H}(W, S)$.

From now on, we will be working with the normalized standard basis $\delta_w := v^{\ell(w)} T_w$ for $\mathcal{H}(W, S)$, where $v := q^{-1/2}$. Normalizing the dual Kazhdan–Lusztig basis, we obtain

$$b_x = v^{\ell(x)} \sum_{y \leq x} P_{y,x}(v^{-2}) v^{-\ell(y)} \delta_y = \sum_{y \leq x} h_{y,x}(v) \delta_y,$$

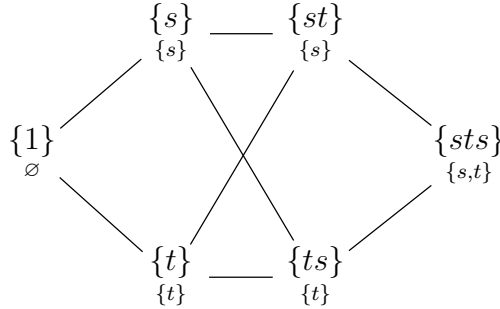
where $h_{y,x} : v \mapsto v^{\ell(x)-\ell(y)} P_{y,x}(v^{-2})$. Recall that $P_{y,x}(q)$ has maximal degree $\frac{1}{2}(\ell(x) - \ell(y) - 1)$ in q . It therefore has degree greater than or equal to $1 + \ell(y) - \ell(x)$ in v , meaning $h_{y,x}(v) \in v\mathbb{Z}[v]$, where the coefficient of $q^{\frac{1}{2}(\ell(x)-\ell(y)-1)}$ in $P_{y,x}(q)$ is now the coefficient of v in $h_{y,x}(v)$. Because $\tau'_s(x)$ corresponds to $T_s \cdot x$, converting to the normalized basis involves multiplying by a factor of $v^{\ell(s)} = v$, whence

$$\delta_x \cdot x := \begin{cases} v^{-1}x, & \text{if } s \in I_x; \\ -vx + \sum_{\{y \in X : s \in I_y\}} \mu(y, x)y, & \text{otherwise.} \end{cases}$$

Using $b_s = \delta_s + v$, we have an action of the normalized Kazhdan–Lusztig basis given pleasantly by

$$b_s \cdot x := \begin{cases} (v + v^{-1})x, & \text{if } s \in I_x; \\ \sum_{\{y \in X : s \in I_y\}} \mu(y, x)y, & \text{otherwise.} \end{cases}$$

Example 2. ($W = S_2$). Let's look at the situation when $W = S_2$. In this case, $P_{y,x}(q) \in \{0, 1\}$ for all $x, y \in W$. Perhaps unsurprisingly, the graph recovers the Bruhat order.



Naturally, all of the edges of this graph have unit weight. We could illustrate the action of b_s by drawing an arrow labelled s from x to y whenever y appears in $b_s \cdot x$, but this would get messy!

2. THE HARISH-CHANDRA PICTURE

Let's briefly mention the connection between admissible representations and (\mathfrak{g}, K) -modules. Good resources for what follows are [Vog81] and [Bin10].

Definition 3. (Continuous Representation). *Let G be a Lie group. A continuous representation of G is a pair (π, \mathcal{H}) , where \mathcal{H} is a complex Hilbert space and $\pi : G \rightarrow \mathcal{B}(\mathcal{H})$ is a continuous homomorphism of G into the semigroup $\mathcal{B}(\mathcal{H})$ of bounded operators on \mathcal{H} , where $\mathcal{B}(\mathcal{H})$ is endowed with the weak topology. An invariant subspace of (π, \mathcal{H}) is a closed subspace of \mathcal{H} that is left invariant under all the operators in $\pi(G)$. The continuous representation (π, \mathcal{H}) is said to be irreducible if $\mathcal{H} \neq \{0\}$ and there are no proper, non-trivial invariant subspaces.*

Definition 4. (Bounded Equivalence). Let (π, \mathcal{H}) and (π', \mathcal{H}') be continuous representations of a Lie group G . We define the space of intertwining operators between (π, \mathcal{H}) and (π', \mathcal{H}') to be

$$\text{Hom}_G(\pi, \pi') := \{L : \mathcal{H} \rightarrow \mathcal{H}' : L \text{ is continuous, linear and } \pi'(g) \circ L = L \circ \pi(g) \text{ for all } g \in G\}.$$

We say that two continuous representations are boundedly equivalent if there exists an invertible intertwining operator between them.

Definition 5. (Dual Object). Let G be a Lie group that is the direct product of a compact group and an Abelian group, such that every irreducible continuous representation of G is finite-dimensional. We define the dual object \widehat{G} of G to be the set of bounded equivalence classes of irreducible continuous representations of G .

Definition 6. (Admissible Representation). Let G be a real Lie group with K a maximal compact subgroup. A continuous representation (π, \mathcal{H}) of G is said to be K -admissible if $\text{Hom}_K(V_\delta, \mathcal{H})$ is finite-dimensional for all irreducible continuous representations $(\delta, V_\delta) \in \widehat{K}$ of K .

Definition 7. (\mathfrak{g}, K) -Module). Let G be a real Lie group with complexified Lie algebra \mathfrak{g} and maximal compact subgroup K . A (\mathfrak{g}, K) -module is a complex vector space V together with a map $\pi : \mathfrak{g} \sqcup K \rightarrow \text{End}(V)$ that restricts to a Lie algebra representation $\pi|_{\mathfrak{g}}$ (that is, V is a $\mathcal{U}(\mathfrak{g})$ -module) and a group representation $\pi|_K$ satisfying certain compatibility conditions. A (\mathfrak{g}, K) -module V is said to be K -admissible if $\text{Hom}_K(V_\delta, V)$ is finite-dimensional for all irreducible continuous representations $(\delta, V_\delta) \in \widehat{K}$ of K . A K -admissible (\mathfrak{g}, K) -module which is finitely-generated over $\mathcal{U}(\mathfrak{g})$ is called a Harish-Chandra module.

Definition 8. (K -Finiteness). Let G be a real Lie group with K a maximal compact subgroup and (π, \mathcal{H}) a continuous representation of G . A vector $v \in \mathcal{H}$ is said to be K -finite if $\text{span}\{\pi(k)v : k \in K\}$ is finite-dimensional. We denote $\mathcal{H}_K := \{v \in \mathcal{H} : v \text{ is } K\text{-finite}\}$.

Theorem 9. ([Vog81, Theorem 0.3.5]). Let G be a real Lie group with Lie algebra \mathfrak{g}_0 and maximal compact subgroup K . If (π, \mathcal{H}) is a K -admissible representation of G , the limit

$$\widehat{\pi}_0(x)v := \lim_{t \rightarrow 0} \frac{\pi(\exp(tx))v - v}{t}$$

exists for all $x \in \mathfrak{g}_0$ and $v \in \mathcal{H}_K$, where $\exp : \mathfrak{g}_0 \rightarrow G$ is the exponential map. In particular, this defines a Lie algebra representation $\widehat{\pi}_0 : \mathfrak{g}_0 \rightarrow \text{End}(\mathcal{H}_K)$. Let $\widehat{\pi}|_{\mathfrak{g}} : \mathfrak{g} \rightarrow \text{End}(\mathcal{H}_K)$ be its complexification, which exists since \mathcal{H} is complex. By definition \mathcal{H}_K induces a group representation $\widehat{\pi}|_K : K \rightarrow \text{End}(\mathcal{H}_K)$, whence these representations endow \mathcal{H}_K with the structure of a (\mathfrak{g}, K) -module.

Definition 10. (Infinitesimal Equivalence). Let (π, V) and (π', V') be (\mathfrak{g}, K) -modules. We define the space of intertwining operators between (π, V) and (π', V') to be

$$\text{Hom}_{(\mathfrak{g}, K)}(\pi, \pi') := \{L : V \rightarrow V' : L \text{ is complex, linear and } \pi'(x) \circ L = L \circ \pi(x) \text{ for all } x \in \mathfrak{g} \sqcup K\}.$$

We say that two (\mathfrak{g}, K) -modules are equivalent if there exists an invertible intertwining operator between them. Two continuous representations are said to be infinitesimally equivalent if their corresponding Harish-Chandra modules are equivalent.

Theorem 11. ([Vog81, Theorem 0.3.10]). *Let G be a real Lie group with complexified Lie algebra \mathfrak{g} and maximal compact subgroup K . Then every irreducible (\mathfrak{g}, K) -module is the Harish-Chandra module of an irreducible K -admissible representation of G . In particular, every irreducible (\mathfrak{g}, K) -module is automatically K -admissible, and we have a bijective correspondence*

$$\begin{array}{ccc} \underbrace{\{\text{irreducible } K\text{-admissible representations of } G\}}_{\text{infinitesimal equivalence}} & \longleftrightarrow & \underbrace{\{\text{irreducible Harish-Chandra modules}\}}_{\text{equivalence}} \\ & & \longleftrightarrow \underbrace{\{\text{irreducible } (\mathfrak{g}, K)\text{-modules}\}}_{\text{equivalence}} \end{array}$$

via Theorem 9.

From now on, we shall assume the following notation. Let \mathbb{G} be a connected, complex, reductive algebraic group defined over \mathbb{R} and G its group of \mathbb{R} -rational points. Let θ be the Cartan involution corresponding to G , and write $\mathbb{K} := \mathbb{G}^\theta$ and $K := G^\theta$ for the corresponding fixed-point subgroups, where we recall that K is necessarily maximal compact (see [AC09, §3] or my notes on categorical representation theory). Denote by \mathfrak{g} the complexification of the Lie algebra of G and let \mathfrak{h} be a Cartan subalgebra of \mathfrak{g} . Finally, let W be the Weyl group of \mathfrak{h} in \mathfrak{g} ([Vog81, Definition 0.2.5]).

If V is an irreducible (\mathfrak{g}, K) -module, Dixmier's generalization of Schur's lemma ([Kna13, Proposition 5.19]) tells us that every endomorphism of an irreducible (\mathfrak{g}, K) -module V is a scalar. In particular, by treating V as a $\mathcal{U}(\mathfrak{g})$ -module, the center $Z(\mathcal{U}(\mathfrak{g}))$ acts on V by

$$z \cdot v = \chi_V(z)v$$

for all $z \in Z(\mathcal{U}(\mathfrak{g}))$ and $v \in V$, where $\chi_V(z) \in \mathbb{C}$. The resulting homomorphism $\chi_V : Z(\mathcal{U}(\mathfrak{g})) \rightarrow \mathbb{C}$ is known as the *infinitesimal character* of V . Two equivalent (\mathfrak{g}, K) -modules will always share the same infinitesimal character.

By [Vog81, Theorem 0.2.8], we have an algebra isomorphism $\xi : Z(\mathcal{U}(\mathfrak{g})) \rightarrow \mathcal{U}(\mathfrak{h})^W$ known as the *Harish-Chandra isomorphism*. Suppose we let $\lambda \in \mathfrak{h}^*$. This corresponds to an algebra homomorphism $\lambda : \mathfrak{h} \rightarrow \mathbb{C}$ and hence lifts to an algebra homomorphism $\lambda : \mathcal{U}(\mathfrak{h}) \rightarrow \mathbb{C}$. Composing the latter map with the Harish-Chandra isomorphism, we obtain a map $\xi_\lambda : Z(\mathcal{U}(\mathfrak{g})) \rightarrow \mathbb{C}$. In fact, we have the following surprising result.

Theorem 12. ([Vog81, Corollary 0.2.10]). *Every homomorphism from $Z(\mathcal{U}(\mathfrak{g}))$ to \mathbb{C} is of the form ξ_λ , for some $\lambda \in \mathfrak{h}^*$. Moreover, $\xi_\lambda = \xi_{\lambda'}$ if and only if there exists some $w \in W$ for which $\lambda' = w\lambda$.*

In other words, if we have a map $\chi : \text{Adm}_K(G) \rightarrow \mathfrak{h}^*/W$ that takes equivalence classes of irreducible K -admissible representations of G to W -conjugacy classes of elements in \mathfrak{h}^* . Given some $\lambda \in \mathfrak{h}^*/W$, we will write

$$\text{Adm}_K(G, \lambda) := \{\pi \in \text{Adm}_K(G) : \chi(\pi) = \lambda\}$$

for the set of equivalence classes of irreducible K -admissible representations of G with infinitesimal character λ . By [Vog81, Corollary 5.4.17], this set is finite.

We shall henceforth fix $\lambda \in \mathfrak{h}^*$ non-singular and integral ($\langle \lambda, \check{\alpha} \rangle \in \mathbb{Z}_+$ for all simple coroots $\check{\alpha} \in \check{\Delta}$).

Definition 13. (Block). *Two irreducible (\mathfrak{g}, K) -modules V and V' are said to be block equivalent if there exists an indecomposable (\mathfrak{g}, K) -module V_B together with a non-split short exact sequence*

$$0 \rightarrow V \rightarrow V_B \rightarrow V' \rightarrow 0.$$

Block equivalence classes are known as blocks.

By [Vog81, Lemma 9.2.3], every (\mathfrak{g}, K) -module V of finite length (that is, every (\mathfrak{g}, K) -module admitting a notion of a Jordan–Hölder series) can be written as a direct sum

$$V = \bigoplus_{\text{blocks } B} V_B,$$

where each V_B is some (\mathfrak{g}, K) -module whose irreducible sub- (\mathfrak{g}, K) -modules all belong to the block B . Moreover, blocks of irreducible (\mathfrak{g}, K) -modules are somehow determined by their infinitesimal characters ([Vog81, Theorem 9.2.11]).

The original definition of a block from [Vog81, Definition 9.2.1] is that two irreducible (\mathfrak{g}, K) -modules are block equivalent if and only if their first cohomology group is non-zero. Blocks give us a way of computing the composition series of certain standard representations, generalizing the algorithm given by Kazhdan and Lusztig for Verma modules in [KL79].

Remark 14. We have been primarily living in the Harish-Chandra world. Atlas, on the other hand, uses a more geometric language, owing to the Langlands classification. Here, every irreducible admissible representation corresponds to a pair (x, y) , where x is a \mathbb{K} -orbit in \mathbb{G}/\mathbb{B} and y is a \mathbb{K}^\vee -orbit in $\mathbb{G}^\vee/\mathbb{B}^\vee$ (see [AC09, §10] and [Ada08, §8]). Here \mathbb{B} is some Borel subgroup of \mathbb{G} , \mathbb{G}^\vee is the Langlands dual of \mathbb{G} , \mathbb{B}^\vee is a Borel subgroup of \mathbb{G}^\vee and \mathbb{K}^\vee is the complexification of a maximal compact subgroup K^\vee of a real form G^\vee of \mathbb{G}^\vee . In this language, a block is a set of the form

$$B(G^\vee) := \{(x, y) \in \mathbb{K} \backslash \mathbb{G}/\mathbb{B} \times \mathbb{K}^\vee \backslash \mathbb{G}^\vee/\mathbb{B}^\vee : \theta_{x,H}^t = -\theta_{y,H}^\vee\},$$

arising from a real form G^\vee . Here $\theta_{x,H}^t = -\theta_{y,H}^\vee$ is a technical compatibility condition. Moreover,

$$\text{Adm}_K(G, \lambda) \longleftrightarrow \bigsqcup_{\text{dual real forms } G^\vee} B(G^\vee).$$

Similarly, the irreducible admissible representations of a real form G^\vee can be broken up into blocks corresponding to real forms of \mathbb{G} ; Vogan duality tells us that if $(x, y) \in \mathbb{K} \backslash \mathbb{G}/\mathbb{B} \times \mathbb{K}^\vee \backslash \mathbb{G}^\vee/\mathbb{B}^\vee$ corresponds to an admissible representation of G , then (y, x) will correspond to an admissible representation of the real form G^\vee of \mathbb{G}^\vee corresponding to \mathbb{K}^\vee .

Before we can start building W -graphs from blocks of irreducible Harish-Chandra modules, we need two more ingredients. The first is a notion of cells within these blocks, first appearing in [BV83].

Definition 15. (Harish-Chandra Cell). *Let x, y be two irreducible Harish-Chandra modules with infinitesimal character λ . Write $y \geq x$ if there exists an irreducible finite-dimensional representation f of G such that y is isomorphic to a composition factor of $f \otimes x$. We say that $x \sim y$ if $y \geq x$ and $x \geq y$. The resulting equivalence classes are known as Harish-Chandra cells.*

Remark 16. Harish-Chandra cells are sometimes called W -cells, since the Harish-Chandra cells of infinitesimal character λ admit an action of the integral Weyl group $W(\lambda)$ and hence correspond to so-called *Harish-Chandra cell representations* of $W(\lambda)$.

Definition 17. (Borho–Jantzen–Duflo τ -Invariant). *Let x be an irreducible Harish-Chandra module with infinitesimal character λ and $R^+(\lambda) := \{\alpha \in \Phi : \langle \lambda, \check{\alpha} \rangle \in \mathbb{Z}_+\}$ the system of positive integral roots defined by λ . The Borho–Jantzen–Duflo τ -invariant of x is the set $\tau(x) \subseteq R^+(\lambda)$ of simple roots satisfying the equivalent conditions of [Vog81, Corollary 7.2.27].*

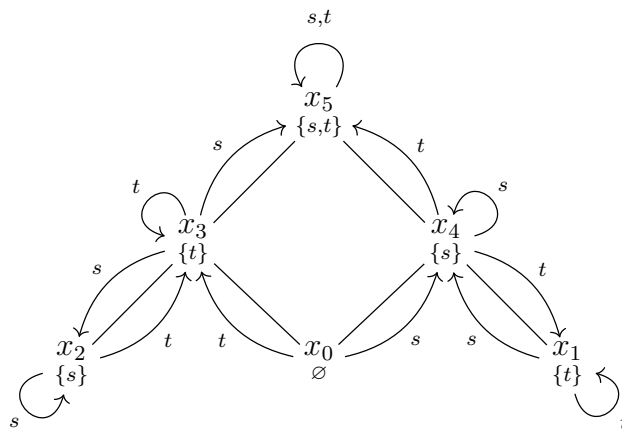
3. THE ATLAS CONSTRUCTION

Let B be a block of irreducible Harish-Chandra modules of infinitesimal character λ . Using the setup from the previous section, we build a W -graph from this block as follows.

- The vertices are the elements $x \in B$.
- Define $\mu(y, x)$ to be the coefficient of v in the Kazhdan–Lusztig–Vogan polynomial $h_{y,x}(v)$.
- Define I_x to be the Borho–Jantzen–Duflo τ -invariant of x (see [Vog81, Definition 7.3.8]).

Unlike the Kazhdan–Lusztig W -graph, this W -graph is directed. Moreover, the strongly connected components of this graph with respect to the Kazhdan–Lusztig–Vogan basis in fact exhaust the Harish-Chandra cells of B , and the multiplicity $\mu(x, y)$ of an edge $x \rightarrow y$ corresponds to the multiplicity with which the representation x appears in $\mathfrak{g} \otimes y$.

Example 18. ($G = \mathrm{SU}(2, 1)$). Let's compute the Kazhdan–Lusztig–Vogan W -graph for $\mathrm{SU}(2, 1)$. This W -graph only has one block, the trivial block, consisting of 6 irreducible representations. Let's write $B = \{x_0, x_1, x_2, x_3, x_4, x_5\}$. The complexification of the Lie algebra of $\mathrm{SU}(2, 1)$ is $\mathfrak{sl}(3, \mathbb{C})$, which has simple roots $\{\alpha, \beta\}$ that we identify with simple reflections $\{s, t\}$. Once again, the multiplicities are all 1 in this example too, and in fact the edges are all bidirectional. Recalling the action of b_s on our vertices induced by τ'_s , we have



We see that the W -cells of this block are $\{x_0\}$, $\{x_1, x_4\}$, $\{x_2, x_3\}$ and $\{x_5\}$.

REFERENCES

- [AC09] Adams, J. and du Cloux, F., *Algorithms for Representation Theory of Real Reductive Groups*, J. Inst. Math. Jussieu **8.2** (2009), pp. 209–259.
- [Ada08] Adams, J., *Guide to the Atlas Software: Computational Representation Theory of Real Reductive Groups*, Contemporary Mathematics **472**, American Mathematical Society, 2008, pp. 1–37.
- [BV83] Barbasch, D. M. and Vogan, D. A., *Weyl Group Representations and Nilpotent Orbits*, Progress in Mathematics **40**, Birkhäuser Boston, 1983, pp. 21–33.
- [Bin10] Binegar, B., *W-Graphs, Nilpotent Orbits, and Primitive Ideals*, Oklahoma State University, 2010, <https://www.birs.ca/workshops/2010/10w5039/files/BinegarDETAILS.pdf>.
- [KL79] Kazhdan, D. and Lusztig, G., *Representations of Coxeter Groups and Hecke Algebras*, Invent. Math. **53** (1979), pp. 165–184.
- [Kna13] Knapp, A. W., *Lie Groups Beyond an Introduction*, Progress in Mathematics **140**, Springer Science & Business Media, 2013.
- [Vog81] Vogan, D. A., *Representations of Real Reductive Lie Groups*, Progress in Mathematics **15**, Birkhäuser Boston, 1981.