

Definition 1. Let a V-map be a u.s.c. idempotent surjection.

Definition 2. For any LOS $\langle L, \leq \rangle$, let \check{L} be the collection of leftward subsets of L (subsets for which $b \in L, a \leq b \Rightarrow a \in L$) linearly ordered by \subseteq , and let \hat{L} be the collection of left-closed subsets of L (leftward subsets which are closed) linearly ordered by \subseteq .

Proposition 3. \check{L}, \hat{L} are compact.

Proof. Each subset S has an infimum $\cap S$ and a supremum $\cup S$ (or $\text{cl}(\cap S)$). \square

Note that \check{L} is not a “compactification” as L does not necessarily embed as a dense subspace of \check{L} : if $L = I$, we might attempt to embed $t \mapsto [0, t)$, but then note that the subspace topology induces the reverse Sorgenfrey interval as $([0, s), [0, t]) = ([0, s), [0, t])$ is open. However \hat{L} is the typical way of compactifying a linearly ordered space L , provided L lacks a least element (otherwise the empty set is an [easily removable] isolated point in \hat{L}).

Definition 4. For any compact LOTS K with minimum 0 and maximum 1, let γ be the V-map on K where $\gamma(0) = K$ and $\gamma(t) = \{1\}$ for $t > 0$.

Definition 5. For any LOTS M with minimum element 0, let ν be the V-map on M where $\nu(0) = K$ and $\nu(t) = \{t\}$ for $t > 0$.

Note for $K = M = 2$ that $\gamma = \nu$.

Theorem 6. $X = \varprojlim \{2, \gamma, L\} \cong \check{L}$

Proof. We start by placing an order on X . Let $\vec{x} < \vec{y}$ if there exists $a \in L$ with $\vec{x}(a) = 0, \vec{y}(a) = 1$. We claim this is a total order inducing the topology on X .

We first observe that if $\vec{x}(b) = 1$, then for all $a \leq b$, $\vec{x}(a) \in \gamma(1) = \{1\}$. If $\vec{x} \neq \vec{y}$, then assume without loss of generality that $\vec{x}(a) = 0, \vec{y}(a) = 1$, so $\vec{x} < \vec{y}$. Also, whenever $\vec{x}(b) = 1$, we have that $b < a$, so $\vec{y}(b) = 1$, preventing $\vec{y} < \vec{x}$. Finally if $\vec{x} < \vec{y}$ and $\vec{y} < \vec{z}$, take a, b with $\vec{x}(a) = 0, \vec{y}(a) = 1, \vec{y}(b) = 0, \vec{z}(b) = 1$. It follows that $a < b$ so $\vec{z}(a) = 1$ and $\vec{x} < \vec{z}$.

Consider the basic open set $B(\vec{x}, F)$ for a finite set $F \in [L]^{<\omega}$ about the sequence $\vec{x} \in X$ which contains all sequences \vec{y} agreeing with \vec{x} on F . If $\vec{x}(a) = 1$ for all $a \in F$, then let $\vec{w} \in X$ be 0 on the maximum of F , and 1 for anything less. It follows that $B(\vec{x}, F) = (\vec{w}, \rightarrow)$. If $\vec{x}(a) = 0$ for all $a \in F$, then let $\vec{y} \in X$ be 1 on the minimum of F , and 0 for anything greater. It follows that $B(\vec{x}, F) = (\leftarrow, \vec{y})$. Finally if $\vec{x}(a) = 1$ and $\vec{x}(b) = 0$ for $a < b$ in F and nothing between a, b is in F , then let $\vec{w} \in X$ be 0 on a and 1 for anything less, and let $\vec{y} \in X$ be 1 on b and 0 for anything greater. It follows that $B(\vec{x}, F) = (\vec{w}, \vec{y})$.

Let ϕ evaluate each $\vec{x} \in X \subseteq 2^L$ as the characteristic function for a subset of L . It's easy to see that ϕ is an order isomorphism between $\langle X, \leq \rangle$ and $\langle \check{L}, \subseteq \rangle$. \square

Corollary 7. $\varprojlim\{2, \gamma, \alpha\} \cong \alpha + 1$ for every ordinal α .

Proof. Since $\hat{\alpha} = \alpha + 1$ (actually equals, not just homeomorphic!), we get $\varprojlim^*\{2, \gamma, \alpha\} \cong \hat{\alpha} = \alpha + 1$ for free. \square

We introduce an alternate definition of an arbitrarily indexed inverse limit.

Definition 8. Let $\varprojlim^*\{X, f, L\} \subseteq \varprojlim\{X, f, L\}$ satisfy that $\vec{x}(a) = \lim_{t \rightarrow a} \vec{x}(t)$ for all $a \in L$ (for any open neighborhood U of $\vec{x}(a)$ there is $b < a$ where $\vec{x}(t) \in U$ for all $t \in (b, a]$).

Theorem 9. $Y = \varprojlim^*\{2, \gamma, L\} \cong \hat{L}$.

Proof. Consider Y as a subspace of $X = \varprojlim\{2, \gamma, L\}$ with the linear order described above. We claim that if ϕ is the characteristic function for a subset of L , then ϕ is an order isomorphism between $\langle Y, \leq \rangle$ and $\langle \hat{L}, \subseteq \rangle$.

Let A be a left-closed subset of L . Let $\vec{x}(a) = 1$ when $a \in A$ and $\vec{x}(a) = 0$ otherwise. Then $\vec{x} \in Y$ and $\phi(\vec{x}) = A$.

Let $\vec{x}, \vec{y} \in Y$. If $\phi(\vec{x}) = \phi(\vec{y}) = A$, then A is a left-closed set where $\vec{x}(a) = \vec{y}(a) = 1$ for $a \in A$ and $\vec{x}(a) = \vec{y}(a) = 0$ otherwise, so $\vec{x} = \vec{y}$.

Finally let $\vec{x} < \vec{y}$, so there exists $a \in L$ with $\vec{x}(a) = 0$, $\vec{y}(a) = 1$. Then $\phi(\vec{x}) \subseteq (\leftarrow, a) \subseteq \phi(\vec{y})$. Thus ϕ preserves order. \square

Corollary 10. $\varprojlim^*\{2, \gamma, \alpha\} \cong \alpha + 1$ for every infinite limit or finite ordinal α .

Proof. If α is finite, then of course all (leftward) sets are closed and we get $\hat{\alpha} = \check{\alpha} = \alpha + 1$ for free. Otherwise, since α lacks a greatest point, $\hat{\alpha}$ is homeomorphic to its usual compactification $\alpha + 1$. \square

In fact, $\hat{\alpha} = \alpha + 1 \setminus L(\alpha)$ where $L(\alpha)$ is the collection of all limit ordinals less than α , which also shows $\hat{\alpha} \cong \alpha$ for infinite successor ordinals α .

The reader may verify the following examples:

Example 11. $\varprojlim\{2, \gamma, I\} \cong \check{L} \times_{\text{lex}} 1$

Example 12. $\varprojlim\{I, \gamma, I\} \cong I \times_{\text{lex}} I$

Example 13. $\varprojlim\{I, \gamma, \omega\} \cong (\omega \times_{\text{lex}} [0, 1)) \cup \{\infty\}$

Example 14. $\varprojlim\{I, \gamma, \omega + 1\} \cong \omega + 1 \times_{\text{lex}} I$

Example 15. $\varprojlim\{I, \gamma, -\omega\} \cong \{-\infty\} \cup (-\omega \times_{\text{lex}} (0, 1])$

Example 16. $\varprojlim\{I, \gamma, I\} \cong I \times_{\text{lex}} I$

Theorem 17. *If K, L are compact linearly orders, then $\varprojlim\{K, \gamma, L\} \cong L \times_{\text{lex}} K$.*

Proof.

□

References