ω^*, ω_1^* and non-trivial autohomeomorphisms

Quidquid latine dictum sit, altum videtur

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Praha, 8. srpen 2011: 15:40–16:10

Outline

A basic question

All cardinals carry the discrete topology.

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Question (The Katowice Problem)

Are there different infinite cardinals κ and λ such that κ^* and λ^* are homeomorphic?

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Gut reaction

Of course not!

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Gut reaction

Of course not! That would be shocking.

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A word of warning

Remember: people thought that $\kappa < \lambda$ would imply $2^\kappa < 2^\lambda$.

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And had a hard time proving it.

And then they learned that it was unprovable.

Very unprovable: one can specify regular cardinals at will and create a model in which their 2-powers are equal.

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A glimmer of hope

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Their sets of isolated points (atoms) have different cardinalities.

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More hope

Theorem (Frankiewicz 1977)

The minimum cardinal κ (if any) such that κ^* is homeomorphic to λ^* for some $\lambda > \kappa$ must be ω.

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Theorem (Balcar and Frankiewicz 1978)

ω_1^* and ω_2^* are not homeomorphic.

Our gut was not completely wrong

Corollary

If $\omega_1 \leqslant \kappa < \lambda$ *then* κ^* *and* λ^* *are not homeomorphic*

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If $\omega_1 \leqslant \kappa < \lambda$ then κ^* and λ^* are not homeomorphic, and if $\omega_2 \leqslant \lambda$ then ω^* and λ^* are not homeomorphic.

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If $\omega_1 \leqslant \kappa < \lambda$ *then* κ^* *and* λ^* *are not homeomorphic, and if* $\omega_2 \leqslant \lambda$ *then* ω^* *and* λ^* *are not homeomorphic.*

So we are left with

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Corollary

If $\omega_1 \leqslant \kappa < \lambda$ then κ^* and λ^* are not homeomorphic, and if $\omega_2 \leqslant \lambda$ then ω^* and λ^* are not homeomorphic.

So we are left with

Question

Are ω^* and ω_1^* ever homeomorphic?

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Outline

1. History
2. Working toward $0 = 1$
3. A non-trivial autohomeomorphism

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Consequences of 'yes'

Easiest consequence: $2^{\aleph_0} = 2^{\aleph_1}$

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So CH implies 'no'.

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We can assume $\gamma[V_n^*] = \bigl(\{n\} \times \omega\bigr)^*$ for all n.

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If $f : \omega \to \omega$ then $e_\alpha \cap f$ is finite for many α and for those α we have $f <^* f_\alpha$.

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And so $\mathrm{MA} + \neg\mathrm{CH}$ implies 'no'.

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Such *strong Q-sequences* exist consistently (Steprāns).

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(Actually second implies third.)

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Then $\tau = \gamma \circ \Sigma^* \circ \gamma^{-1}$ is an autohomeomorphism of ω^*.

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Then $\tau = \gamma \circ \Sigma^* \circ \gamma^{-1}$ is an autohomeomorphism of ω^*.

In fact, τ is non-trivial, i.e., there is no bijection $\sigma : a \to b$ between cofinite sets such that $\tau[x^*] = \sigma[x \cap a]^*$ for all subsets x of ω

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- $\Sigma^*[V_n^*] = V_{n+1}^*$ for all n
- if $V_n^* \subseteq C^*$ for all n then $E_\alpha \subseteq C$ for some α and hence $H_\alpha^* \subseteq C^*$ for all but countably many α.

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which neatly contradicts what's on the previous slide ...

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Some more details

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Split ω into I and F — the unions of the Infinite and Finite orbits, respectively.

An infinite orbit must meet an h_α in an infinite set — and at most two of these.

Why is 'two' even possible?
If the orbit of n is two-sided infinite then both $\{\sigma^k(n) : k \leqslant 0\}^*$ and $\{\sigma^k(n) : k \geqslant 0\}^*$ are τ-invariant.

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It follows that $h_\alpha \subseteq^* F$ for all but countably many α and hence $v_n \cap F$ is infinite for all n.

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Certainly $h_\alpha \setminus c$ is infinite for our co-countably many α.

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Finer detail

- Write each finite orbit as $\{\sigma^k(n) : -l \leqslant k \leqslant m\}$

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- with $n \in v_0$ and $|m - l| \leqslant 1$
- use $\{\sigma^k(n) : -l/2 \leqslant k \leqslant m/2\}$ as a constituent of c.

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Veličković' analysis of autohomeomorphisms of ω^* shows that the ones that are remotely describable (by Borel maps say) are trivial.
Our Σ is very trivial, so it's the putative homeomorphism γ that is badly describable.

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None of which I have been able to prove ...

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More Info

Website: `http://fa.its.tudelft.nl/~hart`

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