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**Title:** Über Folgen stetiger Funktionen  
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In this paper Hurewicz considers sequences of continuous real-valued functions on metrizable spaces  $M$ . For such a sequence  $(f_n : n < \infty)$  of continuous real-valued functions he considers the subset  $\{(f_n(p) : n < \infty) : p \in M\}$  of  ${}^\omega\mathbb{R}$  of sequences of real numbers. This is called the value set of the sequence of functions. He defines the usual notions of being bounded and of not being a dominating family in the eventual domination order on  ${}^\omega\mathbb{R}$ .

In section 2 (p. 194) Hurewicz observes:

**A)** If  $M$  is a union of countably many compact subsets, then the value-set of any sequence of continuous real-valued functions on  $M$  is bounded.

In section 3 (p. 194) he gives an example that

**B)** If  $M$  is the set of irrational real numbers between 0 and 1 then there is a sequence of continuous functions on it whose value set is a dominating family. And for each  $n$  he defines the function  $f_n$ 's value at  $x$ ,  $f_n(x)$ , to be the  $n$ -th term in the continued fraction expansion of  $x$ . He observes that each  $f_n$  is continuous and that the value set of this sequence is the set of all  $\omega$ -sequences of natural numbers. Then he states that from these observations the question arises: What internal properties of a set  $M$  are characterized by the fact that the value set of any sequence of real-valued continuous functions on it is bounded (respectively not dominating)?

In section 4 (p. 195-6) he introduces covering properties  $E^*$  and  $E^{**}$ .

In the current SPM notation,  $E^* = S_{fin}(O, O)$  and  $E^{**} = U_{fin}(O, \Gamma)$ , where  $O$  denotes the collection of open covers of a space, and  $\Gamma$  denotes the collection of open  $\gamma$  covers. Thus  $E^*$  is also what is called the Menger property, and  $E^{**}$  is what is called the Hurewicz property. Then Hurewicz proves

**C)**  $S_{fin}(O, O) = S_{fin}(\Lambda, \Lambda)$

and he observes that

**D)**  $S_{fin}(O, O)$  is preserved by continuous images (Footnote 2, page 195).

In footnote 1 on p. 196 Hurewicz states that evidently  $E^{**}$  implies  $E^*$ , and notes that it is an open problem whether there is a set with property  $E^*$  but not property  $E^{**}$ . Then an additional remark is added during the corrections stage of the paper ("Zusatz bei der Korrektur"): In the remark Hurewicz proves:

**E)** If  $M$  is a subset of a separable metric space and has property  $E^{**}$  but empty interior in the space, then  $M$  is of first category.

This might be due to Sierpinski, on account of the following. Hurewicz states that Sierpinski observed that if the Continuum Hypothesis (CH) holds then the open problem has a positive answer. The argument is as follows: The Lusin set has property  $E^*$ , but because of **E)**, does not have property  $E^{**}$ .

**F)** A Lusin set has property  $S_{fin}(O, O)$  but not property  $U_{fin}(O, \Gamma)$ .

In section 5 (p. 196 - 199) Hurewicz proves the following theorem:

**G)** For a separable metric space  $M$  the following are equivalent:

- (1)  $M$  has property  $S_{fin}(O, O)$  (respectively  $U_{fin}(O, \Gamma)$ ).
- (2) Every sequence of continuous real-valued functions on  $M$  has a non-dominating (respectively bounded) value set.

and then adds

**H)** For a separable metric space  $M$  the following are equivalent:

- (1)  $M$  has property  $S_{fin}(O, O)$ .
- (2) For any sequence  $(f_n : n < \infty)$  of continuous real-valued functions on  $M$ , if the sequence  $a$  of real numbers does not belong to the value set of  $(f_n : n < \infty)$ , then there are sequences  $\beta$  and  $\gamma$  of real numbers such that
  - (a)  $\beta < a < \gamma$  and
  - (b) No  $\xi$  in the value set of  $(f_n : n < \infty)$  satisfies  $\beta < \xi < \gamma$ .
 (For this property Hurewicz uses the terminology “the value set of  $(f_n : n < \infty)$  is closed”.)

In Section 6 (p. 199 - 200) Hurewicz discusses Menger’s Conjecture that in metrizable spaces  $S_{fin}(O, O)$  implies  $\sigma$ -compactness. He reminds the reader that in his 1925 paper he proved that this conjecture is true for analytic sets, and then remarks that the characterization in G) above characterizes the  $\sigma$ -compact sets among the analytic sets as those on which the value sets of a sequence of continuous real-valued functions is bounded. He also observes that Sierpinski showed that the Continuum Hypothesis implies the negation of Menger’s Conjecture. Then, on page 200 Hurewicz conjectures that  $U_{fin}(O, \Gamma)$  is equivalent to  $\sigma$ -compactness.

In Section 7 (p. 201 - 202) Hurewicz connects this study with problems of Hausdorff -whether there is an unbounded sequence of ordertype  $\omega_1$  in the eventual domination order on sequences of reals, or such a dominating sequence. Though Hurewicz considers the first uncountable cardinal number, his next result adapts directly to the modern dominating number and bounding number:

**I)** The minimal cardinality of an unbounded set in  ${}^\omega\mathbb{R}$  is the same as the minimal cardinality of a separable metric space without property  $U_{fin}(O, \Gamma)$ .  
and he states that quite analogously one proves

**J)** The minimal cardinality of a dominating set in  ${}^\omega\mathbb{R}$  is the same as the minimal cardinality of a separable metric space without property  $S_{fin}(O, O)$ .

Supplementary Section (p. 202 - 204) In this supplementary section Hurewicz proves:

**K)** For a metrizable space  $M$  the following are equivalent:

- (1)  $M$  has property  $U_{fin}(O, \Gamma)$ .
- (2) Each metrizable continuous image of  $M$  is a union of countably many totally bounded sets.

Thus, a subspace of a metrizable space has property  $U_{fin}(O, \Gamma)$  if, and only if, it is sigma-totally bounded. He then reformulates the question behind his conjecture. If a metrizable space has property (2) of K), must it be  $\sigma$ -compact? And in the footnote on page 204 Hurewicz notes that similarly:

**L)** For a metrizable space  $M$  the following are equivalent:

- (1)  $M$  has property  $U_{fin}(O, O)$ .

- (2) Each metrizable continuous image of  $M$  is a union of countably many sets whose diameters converge to zero.

**Remarks:**

- 1) Notation: Menger used the symbol  $E$  to denote a basis property which he introduced in his 1924 paper. In his 1925 paper where Hurewicz studied Menger's basis property, he used the symbol  $E^*$  to denote a covering equivalent to Menger's basis property. In the current SPM notation, the property  $E^*$  is denoted  $S_{fin}(O, O)$  where  $O$  denotes the collection of open covers of a space. And Hurewicz introduced in the 1925 paper a second covering property which was denoted by the symbol  $E^{**}$ . In the current SPM notation, property  $E^{**}$  is denoted  $S_{fin}(\Omega, O^{gp})$ .
- 2) Hurewicz was familiar with the 1909 papers by Hausdorff on the eventual domination order, and with Hausdorff's 1917 monograph "Set Theory".