

Clearly, this problem is only interesting if  $X$  has at least 2 points.

So we can pick  $a, b \in X$  s.t.  $a \neq b$ .

Let  $r = d(a, b)$ , the distance between  $a$  and  $b$ . Then  $r > 0$ .

Now, consider the sets

$A_s = \{q \in X \mid d(a, q) = s\}$  - the set of points in  $X$  that is distance  $s$  from  $a$ , for  $\forall s \in (0, r)$ .

Since there are uncountable many such  $s$  values and only countable many points in  $X$ ,  $\exists s_0 \in (0, r)$  s.t.

$A_{s_0} = \emptyset$  (in fact, uncountable many such  $s_0$ ).

Then let

$$U = \{q \in X \mid d(a, q) < s_0\} = B_a(s_0)$$

$$V = \{q \in X \mid d(a, q) > s_0\}$$

Clearly,  $a \in U$ ,  $b \in V$  so  $U, V \neq \emptyset$ .

$U$  is an open ball, so as we proved  $U \in \hat{\mathcal{T}}_d$ . Also  $V \in \mathcal{T}_d$  by a previous homework.

Clearly,  $U \cap V = \emptyset$  and  $X = U \cup V$ .

So  $X$  is disconnected.