



# Generated Sigma Algebra

## 1 Why

A simple way to obtain a sigma algebra, is to ask it to obtain some sets, and then to ask it to contain all the sets it needs to fulfill the properties.

## 2 Definition

The *generated sigma algebra* for a set of subsets is the smallest sigma algebra containing the set of subsets. We must prove the existence and uniqueness of this sigma algebra.

**Proposition 1.** *The intersection of a non-empty set of sigma algebras on the same base set is a sigma algebra.*

*Proof.* Let  $\{(A, \mathcal{A}_\alpha)\}_{\alpha \in I}$  a family of sigma algebras on the same base set. Define  $\mathcal{A}$  as  $\cap_{\alpha \in I} \mathcal{A}_\alpha$ .

1. For all  $\alpha \in I$ ,  $A \in \mathcal{A}_\alpha$ , thus  $A \in \mathcal{A}$ ; condition (a).
2. For all  $B \in \mathcal{A}$ , for all  $\alpha \in I$ ,  $B \in \mathcal{A}_\alpha$ . Thus, for all  $\alpha \in I$ ,  $C_A(B) \in \mathcal{A}_\alpha$ . And so  $C_A(B) \in \mathcal{A}$ ; condition (b).

3. For all sequences  $\{B_n\} \subset \mathcal{A}$ ,  $\{B_n\} \subset \mathcal{A}_\alpha$  for all  $\alpha$ . Thus  $\cup_n B_n \in \mathcal{A}_\alpha$  for all  $\alpha$  and so  $\cup_n B_n \in \mathcal{A}$ ; condition (c).

□

On the other hand, the union of a set of sigma algebras can fail to be a sigma algebra.

**Proposition 2.** *If  $A$  is a set and  $\mathcal{A} \subset 2^A$ , then there is a unique smallest sigma algebra containing  $\mathcal{A}$ .*

*Proof.* We know of one sigma algebra containing  $\mathcal{A}$ : the power set of  $A$ . Thus, the set of sigma algebras containing  $\mathcal{A}$  is not empty. Proposition 1 implies the intersection of all such sigma algebras (containing  $\mathcal{A}$ ) is a sigma algebra. The intersection contains  $\mathcal{A}$ , and is contained in all other sigma algebras with this property, so is a smallest sigma algebra containing  $\mathcal{A}$ . If  $\mathcal{B}, \mathcal{C}$  were two smallest sigma algebras, then  $\mathcal{B} \subset \mathcal{C}$  and  $\mathcal{C} \subset \mathcal{B}$ , but then  $\mathcal{B} = \mathcal{C}$ ; thus the smallest sigma algebra is unique. □

### 3 Notation

Let  $A$  be a set and  $\mathcal{A} \subset 2^A$ . We denote the sigma algebra generated by  $\mathcal{A}$  by  $\sigma(\mathcal{A})$ .