

Dirichlet characters and field extensions

Diaa Al Saleh

Definition 1 A Dirichlet character modulo n is a character of $(\mathbb{Z}/n\mathbb{Z})^\times$. In other words a multiplicative homomorphism

$$\chi : (\mathbb{Z}/n\mathbb{Z})^\times \rightarrow S^1$$

We call n the modulus of χ

Example. Let i be the usual complex number. Define $(\mathbb{Z}/5\mathbb{Z})^\times \rightarrow S^1$ by $\chi(1) = 1, \chi(2) = i, \chi(3) = -i, \chi(4) = -1$

Definition 2 The *conductor* f_χ is the minimal modulus for a Dirichlet character, i.e. χ is not induced by any Dirichlet character of modulus smaller than f_χ . A Dirichlet character with modulus f_χ is called *primitive*.

Now given a fixed positive integer n , the Dirichlet characters having conductors dividing n form a finite group. If we let ζ_n be a primitive n -th root of unity, we can identify $G = \text{Gal}(\mathbb{Q}(\zeta_n)/\mathbb{Q})$ with $(\mathbb{Z}/n\mathbb{Z})^\times$. So a Dirichlet character can be thought as a character on G .

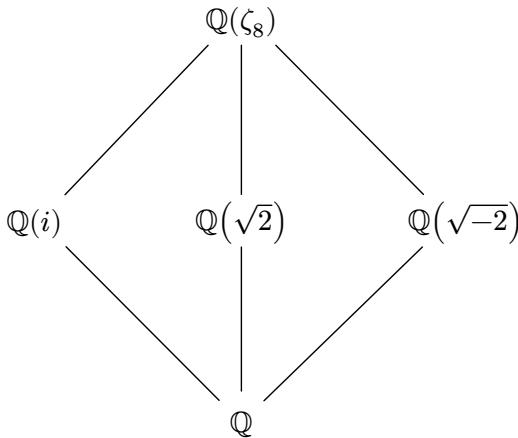
Definition 3 Let χ be a character of G . The fixed field K associated to χ is the fixed field of the kernel of χ

Example.

Let $\chi : G = \text{Gal}(\mathbb{Q}(\zeta_8)/\mathbb{Q}) \rightarrow S^1$ by $\chi(\sigma_1) = 1, \chi(\sigma_3) = -1, \chi(\sigma_5) = 1, \chi(\sigma_7) = -1$, where $\sigma_j : \zeta_{12} \rightarrow \zeta_{12}^j$. Then $\ker \chi = \{\sigma_1, \sigma_5\}$.

It's elementary to see that the fixed field is $\mathbb{Q}(i)$.

Instead if we set $\chi(\sigma_7) = 1$ then the fixed field is real since σ_7 is complex conjugation.



From this we can see that the fixed field is $\mathbb{Q}(\sqrt{2})$