

Seminar Darstellungstheorie

Halbeinfache Moduln und Algebren, Satz von Wedderburn-Artin

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7.-9. Dezember 2007

1 Halbeinfache Moduln

1.1 Definition

Sei R ein Ring. Ein R -Modul M heißt einfach, falls $M \neq 0$ und M keine anderen Untermoduln außer 0 und M selbst besitzt.

1.2 Satz

Sei $M = \sum_{i \in I} S_i$ mit einfachen Untermoduln S_i . Sei N ein Untermodul von M . Dann gibt es eine Teilmenge J von I , so dass gilt:

$$M = N \oplus \left(\bigoplus_{j \in J} S_j \right).$$

Beweis: Zunächst wähle man sich eine Teilmenge $J \subset I$ mit der Eigenschaft, dass $N \cap \left(\sum_{j \in J} S_j \right) = 0$ gilt und die Summe $\sum_{j \in J} S_j$ direkt ist. (Z.B. erfüllt die leere Menge die beiden Eigenschaften, daher ist es legitim anzunehmen, dass es eine solche maximale Teilmenge J gibt.) Dann ist $N + \sum_{j \in J} S_j$ eine direkte Summe. Somit bleibt nur noch zu zeigen, dass diese Summe ganz M ergibt.

Nach Voraussetzung ist M Summe einfacher Untermoduln S_i , $i \in I$. Sei dann \mathcal{X} die Menge aller Untermoduln V von M mit $V \cap N = 0$. Klar ist, dass $\mathcal{X} \neq \emptyset$, denn z.B. ist $0 \in \mathcal{X}$. Sei dann $L = \sum_{j \in J} S_j$ ein maximales Element von \mathcal{X} . Nach obiger Betrachtung ist dann die Summe direkt:

$$N + L = N + \left(\sum_{j \in J} S_j \right) = N \oplus \left(\sum_{j \in J} S_j \right).$$

Wir nehmen nun an, dass $N + L \neq M$ gilt. Dann kann, da M nach Voraussetzung die Summe einfacher Untermoduln ist, nicht jeder einfache Untermodul in $N + L$ liegen.

Sei etwa S_i , $i \in I \setminus J$ ein einfacher Untermodul mit $S_i \not\subseteq N + L$. Dann ist $S_i \cap (N + L)$ ein echter Untermodul von S_i , wegen der Einfachheit gilt also $S_i \cap (N + L) = 0$. Insbesondere gilt dann $S_i \cap N = 0$. Dies impliziert $S_i \in \mathcal{X} \Rightarrow S_i + L = S_i + \sum_{j \in J} S_j \in \mathcal{X}$. Nun ist $L = \sum_{j \in J} S_j$ maximal, daher gilt $L + S_i = L$, und somit $S_i \subset L$. Es gilt aber auch $S_i \cap L = 0$. Dies ist ein Widerspruch. Also gilt: $M = N \oplus \left(\sum_{j \in J} S_j \right)$.

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Seminar Über Funktionen Algebren Lnm 1

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