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译文

固体的统计细观力学---连接多个耦合的时空尺度

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摘要 从固体力学所面临的新的挑战------多物理、多尺度耦合及其现状的描述开始, 以层裂过程为例, 说明了这些多尺度非平衡问题的基本困难在于, 在固体中不同尺度上有不同的微结构层次及不同的演化物理和速率. 接下来, 概述了一些针对这一困难的独特的思路及其成果. 第3部分强调了一些统计平均方法的范式, 以及处理包含多个时间和空间尺度的问题的新思路, 特别是非平衡损伤演化导致宏观失效的问题. 在第4部分, 简要评述了一些连接多个空间和时间尺度的细观力学框架, 如位错理论, 物理细观力学, Weibull理论, 随机理论等, 并且阐述了其中蕴含的跨尺度耦合的机理. 然后, 在第5部分, 回到了描述损伤演化过程的框架, 也就是统计细观损伤力学以及它的跨尺度封闭近似. 基于这些跨尺度框架, 在第6部分, 对控制跨尺度耦合的可能机理进行了评述和比较. 由于对失效时灾变的洞察与跨尺度强耦合紧密相关, 一些非平衡和强相互作用的新概念在第7部分进行了讨论. 最后, 以一个简短的总结和一些建议结束.

关键词 统计细观力学, 多时空尺度, 多物理耦合 跨尺度关联

分类号

STATISTICAL MESOMECHANICS OF SOLID, LINKING COUPLED MULTIPLE SPACE AND TIME SCALES

Abstract

This review begins with the description of a new challenge in solid mechanics: multiphysics and multiscale coupling, and its current situations. By taking spallation as an example, it is illustrated that the fundamental difficulty in these multiscale nonequilibrium problems is due to the hierarchy and evolution of microstructures with various physics and rates at various length levels in solids. Then, some distinctive thoughts to pinpoint the obstacles and outcome are outlined. Section 3 highlights some paradigms of statistical averaging and new thoughts to deal with the problems involving multiple space and time scales, in particular the nonequilibrium damage evolution to macroscopic failure. In Sec.4, several frameworks of mesomechanics linking multiple space and time scales, like dislocation theory, physical mesomechanics, Weibull theory, and stochastic theory, are briefly reviewed and the mechanisms underlying the trans-scale coupling are elucidated. Then we turn to the frameworks mainly concerning damage evolution in Sec.5, namely, statistical microdamage mechanics and its trans-scale approximation. Based on various trans-scale frameworks, some possible mechanisms governing the trans-scale coupling are reviewed and compared in Sec.6. Since the insight into the very catastrophic transition at failure is closely related to strong trans-scale coupling, some new concepts on nonequilibrium and strong interaction are discussed in Sec.7. Finally, this review is concluded with a short summary and some suggestions.

Key words statistical mesomechanics multiple space and time scales coupling of multiple physics trans-scale correlation

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