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# Serration and noise behaviors in materials

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ABSTRACT

Serration and noise behaviors in plastically deforming solids are related to avalanches of deformation processes. In the stress-strain curves, the serration characteristics are visible as stress drops or strain jumps. In fact, similar serration characteristics are ubiquitous in many structural and functional materials, such as amorphous materials [also metallic glasses, or bulk metallic glasses (BMGs)], high-entropy alloys (HEAs), superalloys, ordered intermetallics, shape-memory alloys (SMAs), electrochemical noise, carbon steels, twinning-induced plasticity steels (TWIP steels), phase-transformation-induced plasticity steels (TRIP steels), Al-Mg alloys, nano-materials, magnetic functional materials, and so on. Because of their unique and universal properties, many researchers have focused on this field to find out what causes the serration behaviors and what can be learned about the material from the serration characteristics. For example, the serration characteristics contain information about the mechanisms of plastic deformation and the structural evolution during deformation. However, due to many factors affecting the serration behavior and some uncertain or uncontrolled factors, it's a difficult task to give a unified picture of a vast amount of serration data. This review article summarizes the results of previous studies in this rapidly-developing field, attempting to provide a new perspective in expounding the connection between macroscopic properties and micro-mechanisms.

In this review paper, serration behavior of a wide range of materials will be discussed. One of the most important goals is to investigate the factors influencing serration characteristics and deformation mechanisms. Several statistical properties, such as distributions of stress drop sizes and waiting times, are reviewed and used to quantify the serration behavior. Moreover, models and theories on the serrated flow will be discussed, which quantify the deformation mechanism and provide physical intuition for the experiments, and methods to organize experimental data. Besides discussing serrations in stress-strain curves of many solid materials, this review paper will also cover other systems with serrations and collective noise, such as crackling noise in the earth's crust (earthquakes), volume fluctuations in a granular medium and jamming behavior in random-packing systems.



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**Contents**



## 1. Introduction

The term serrations originally refers to zig-zag shapes like the saw-like shapes of leaves. In many physical systems the term refers to the sudden jerky response to an external driving force or field. In this review paper, serrations are used to refer to the sudden stress drops or strain jumps in the jerky stress-strain curves of solid materials. The loading typically refers to