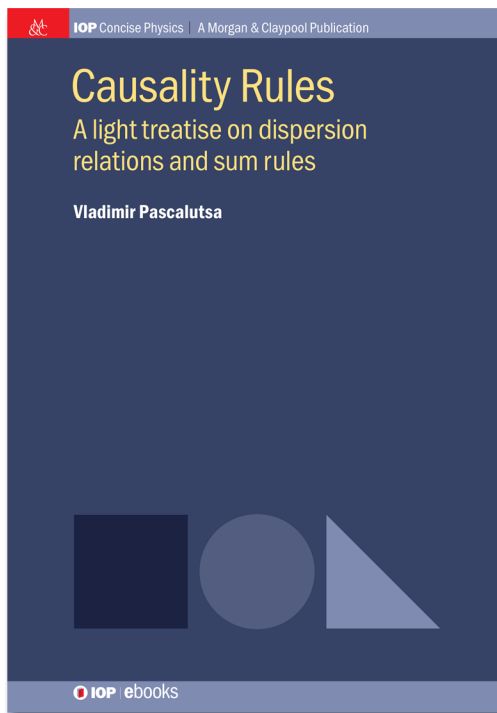


▶ How the quantum process of scattering of light, by light, can be described entirely in terms of classical quantities and how these principles emerge within the Standard Model of particle physics.



## Causality Rules

*A Light Treatise on Dispersion Relations and Sum Rules*

Vladimir Pascalutsa, *Johannes Gutenberg University*

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Scattering of light by light is a fundamental process arising at the quantum level through vacuum fluctuations. This short book will explain how, remarkably enough, this quantum process can entirely be described in terms classical quantities, which are the “-fusion cross sections.” This description is derived from general principles, such as causality, unitarity, Lorentz and gauge symmetries. The reader will thus be introduced into a rigorous formulation of these fundamental concepts, as well as their physical interpretation in the context of light-by-light scattering. The book will also demonstrate how these principles

emerge from quantum loop calculations of light-by-light scattering within the Standard Model (SM) of particle physics. The final chapter of the book will give a survey of timely applications of the light self-interaction. They range from non-linear optics to precision measurements of the muon anomaly ( $g \neq 2$ ) $\mu$ , from dispersion of “-rays in Cosmic Microwave Background (CMB) to the very recent discovery of light-by-light scattering at the Large Hadron Collider (LHC) at CERN.

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Vladimir Pascalutsa is a tenured scientist at the Institute for Nuclear Physics of the Johannes Gutenberg University of Mainz, Germany. Prior to this, he studied and researched at the Kiev State University and Kernfysisch Versneller Instituut (KVI), before obtaining his PHD at the Institute for Theoretical Physics in Utrecht. He also held postdoctoral positions at NIKHEF (Amsterdam, the Netherlands), Flinders University (Adelaide, Australia), Ohio University (Athens OH, USA), College of William and Mary (Williamsburg VA, USA), and the ECT\* (Trento, Italy).

### CONTENTS

Introduction and outline  
Some rules for sum rules  
Kramers' Kronig relation  
Sum rules for Compton scattering  
Virtual and quasi-real Compton scattering  
Sum rules for light-by-light scattering  
Sum rules for vector bosons

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