INTRODUCTION

The Electron Stopwatch

Attosecond Spectroscopy

CONTENTS

Reviews

THE PRECISION ATTAINABLE IN TIMING EVENTS ONCE DEPENDED ON HOW fast a human being could press the button on a stopwatch. More recently, pulsed laser sources have taken the place of those hand-held devices for measuring the fastest phenomena. The technology for tracking the time scale of nuclear motion in free molecules and solids was limited by the duration of a single cycle of visible light: approximately 0.000000000000001 second, or 1 femtosecond. Electrons move even faster than that, and for a long time, scientists could only watch their rearrangements as an indiscrete blur. Over the past several years, however, laser technology has crossed the threshold into the attosecond regime (a thousandth of a femtosecond). This series of three Reviews highlights the methods underlying this advance and the scientific prospects they have enabled.

Bucksbaum (p. 766) lays out the essential physics of high harmonic generation, a technique whereby an intense laser field pulls an atomic electron away from the nucleus like a loaded slingshot and then sends it careening back, giving rise to the emission of an attosecond light pulse. The Review also describes in general terms what events such light pulses can be used to track, ranging from electron rearrangements in chemical bonding to conduction dynamics in metallic solids.

Goulielmakis *et al.* (p. 769) take a more in-depth look at the laser techniques that create and detect attosecond pulses. Their Review also details the prospects not only of passively probing electron motions, but of actively manipulating and controlling them.

In keeping with the uncertainty principle, compressing a light pulse's duration must also broaden its spectral bandwidth. Thus, attosecond pulses extend into the x-ray region of the electromagnetic spectrum. Kapteyn *et al.* (p. 775) describe efforts to harness this feature of the technology in diffraction and imaging experiments, which would otherwise depend on much more elaborate x-ray generation apparatus.

Optical technology continues to evolve. It seems that just as events at the atomic scale are at last observed with precision, they bring into view a new series of blurs, previously unappreciated. Then the quest begins for an even faster stopwatch.

– IAN OSBORNE AND JAKE YESTON

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