Saas-Fee Advanced Course 33

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Gravitational Lensing: Strong, Weak and Micro

Saas-Fee Advanced Course 33

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Cover picture: (Left) Matterhorn, Zermatt, Switzerland, as seen in all its usual beauty (Kurt Müller, http://photo.zermatt.ch). *(Right)* Another vision of the same mountain, as observed on 1 April 2003, while suffering from the transiant phenomenon of a passing-by black hole of one Jupiter mass (with the help of B. McLeod, CfA, Castle, and F. Summers, STScI)

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To the memory of Dennis Walsh (12 June 1933–1 June 2005)
who, with his two colleagues Bob Carswell and Ray Weymann,
discovered in 1979 the first extragalactic gravitational lens, the
quasar QSO 0957+0561

Preface

The observation, in 1919 by A.S. Eddington and collaborators, of the gravitational deflection of light by the Sun proved one of the many predictions of Einstein's Theory of General Relativity: The Sun was the first example of a gravitational lens.

In 1936, Albert Einstein published an article in which he suggested using stars as gravitational lenses. A year later, Fritz Zwicky pointed out that galaxies would act as lenses much more likely than stars, and also gave a list of possible applications, as a means to determine the dark matter content of galaxies and clusters of galaxies.

It was only in 1979 that the first example of an extragalactic gravitational lens was provided by the observation of the distant quasar QSO 0957+0561, by D. Walsh, R.F. Carswell, and R.J. Weymann. A few years later, the first lens showing images in the form of arcs was detected.

The theory, observations, and applications of gravitational lensing constitute one of the most rapidly growing branches of astrophysics. The gravitational deflection of light generated by mass concentrations along a light path produces magnification, multiplicity, and distortion of images, and delays photon propagation from one line of sight relative to another. The huge amount of scientific work produced over the last decade on gravitational lensing has clearly revealed its already substantial and wide impact, and its potential for future astrophysical applications.

The 33rd Saas-Fee Advanced Courses of the Swiss Society for Astronomy and Astrophysics, entitled *Gravitational Lensing: Strong, Weak, and Micro*, took place from 8–12 April, 2003, in Les Diablerets, a pleasant mountain resort of the Swiss Alps. The three lecturers were Peter Schneider, Christopher S. Kochanek, and Joachim Wambsganss.

These proceedings are provided in four complementary parts of a book on gravitational lensing. P. Schneider wrote Part 1, *Introduction to Gravitational Lensing and Cosmology*, the first draft of which was made available to all registered participants a week before the course. C.S. Kochanek wrote Part 2 about *Strong Gravitational Lensing*, while P. Schneider in Part 3 dealt with

Weak Gravitational Lensing, and J. Wambsganss in Part 4 about *Gravitational Microlensing*.

We are thankful to Nicole Tharin, the secretary of the Laboratoire d'Astrophysique de l'Ecole Polytechnique Fédérale de Lausanne (EPFL), for her continuous presence and efficient help, and to Yves Debernardi for his efficient logistic support during the course. We are equally thankful to Frédéric Courbin, Dominique Sluse, Christel Vuissoz, and Alexander Eigenbrod for help in the editorial process of this book.

The meeting was also sponsored by the Université de Lausanne, the Ecole Polytechnique Fédérale de Lausanne (EPFL), the Swiss Society for Astronomy and Astrophysics, the Académie Suisse des Sciences Naturelles, the Fonds National Suisse de la Recherche Scientifique, the Space Telescope Science Institute, the Universität Zürich, and the Observatoire de Genève.

Lausanne,
July 2005

Georges Meylan
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