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Impacts on Earth

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Editors' Preface

by Daniel Benest and Claude Froeschlé

Cosmic Impacts

At the beginning of the 19th century, astronomers discover the first asteroids ... and the academics recognize that stones may fall from the extra-atmospheric space. Half a century later, many other asteroids had been discovered, and Daniel Kirkwood found that there were gaps in their semi-major axis distribution, corresponding to mean motion resonances with Jupiter. As discovered in 1918 by Kiyotsugu Hirayama, some groups are apparent in the frequency distribution of the orbital elements of these minor planets, which he called *families*; Hirayama suggested that the origin of these families could come from a catastrophic break-up of a common parent body. Finally, since the 80's, modern celestial mechanics and dynamical planetology have begun to explain the processes that send asteroids on trajectories crossing the Earth's orbit. This will be developed in Part I of this book.

We know now that impact phenomena play an essential role in the formation of planets – and of other minor bodies orbiting the Sun – and keep a great influence during their evolution; impacts have therefore a non negligible importance in the history (particularly from the point of view of geology) of the Solar System. Part II describes some physical processes consecutive to the impact on a lithosphere, and Part III discusses the dating of ancient impacts on Earth together with some considerations about hazards due to space debris orbiting our planet.

Impacts cosmiques

Au début du XIX^{e} siècle, les astronomes découvrent les premiers astéroïdes ... et les Académiciens reconnaissent que des cailloux peuvent tomber du ciel. Un demi-siècle plus tard, de nombreux autres astéroïdes avaient été découverts, et Daniel Kirkwood détecta des lacunes dans leur distribution spatiale en demi-grand axe, qui correspondent à des résonances en moyen mouvement avec Jupiter. En 1918, Kiyotsugu Hirayama mit en évidence certains groupements dans la distribution en fréquence des éléments orbitaux de ces petites planètes, qu'il nomma *familles*; Hirayama suggéra que l'origine de ces familles pourrait se situer lors du brisement catastrophique d'un corps "parent". Finalement, depuis

les années 80, la mécanique céleste moderne et la planétologie dynamique commencent à comprendre les mécanismes qui envoient des astéroïdes sur des trajectoires qui croisent l'orbite de la Terre. Ce qui est développé dans la Partie I du présent ouvrage.

Nous savons maintenant que les phénomènes d'impact jouent un rôle essentiel dans la formation des planètes – et des autres petits corps qui orbitent autour du Soleil –, et conservent une grande influence au cours de leur évolution; les impacts ont donc une importance non négligeable dans l'histoire du Système Solaire (particulièrement du point de vue de la géologie). La Partie II éclaire certains processus physiques consécutifs aux impacts sur une lithosphere, et la Partie III expose les méthodes de datation des impacts terrestres anciens, ainsi que quelques considérations à propos des dangers que peuvent faire courir les débris spatiaux en orbite autour de notre planète.

The Goutelas School

The Spring School of Astronomy and Astrophysics of Goutelas has taken p[lace since 1977. Founded by Evry Schatzman, of the French Sciences Academy, the school is held annually at Goutelas Castle in the Forez country (Haute-Loire, France), under the patronage of the S.F.S.A. (Société Française des Spécialistes d'Astronomie) and with the financial support of the C.N.R.S. (the French "Centre National de la Recherche Scientifique") through its "Continuing Formation" department. The manager and the staff of the "Centre Culturel de Goutelas" contribute a lot to the success of the school, as they do their best to provide pleasant and friendly surroundings.

In the past, for the schools of 1989 and 1991 to and for other meetings, we had already proposed topics closely related to the dynamics of minor bodies in the Solar System, or about techniques used in dynamical planetology (see references). The 18th Goutelas School was held during 2nd-7th May 1994, and was devoted to the study of these impact phenomena, and particularly those affecting our planet, the Earth. This book is born from the courses given in this school, and the chapters have been updated.

Last but not the least, we were assisted by Monique Fulconis, with all her efficiency and kindness.

L'École de Goutelas

L'École de Printemps d'Astronomie et d'Astrophysique de Goutelas existe depuis 1977. Fondée par Evry Schatzman, de l'Académie des Sciences, l'École se tient annuellement au Château de Goutelas dans le Forez (Haute-Loire, France), sous le parrainage de la Société Française des Spécialistes d'Astronomie et avec le soutien financier de la Formation Permanente du Centre National de la Recherche Scientifique. Le succès de cette École tient pour une bonne part dans l'efficacité et la gentillesse de l'accueil du personnel du Centre Culturel de Goutelas.

Déjà, lors des Écoles de 1989 et 1991 – ainsi que lors d'autres réunions –, nous avions proposé des thèmes proches de la dynamique des petits corps du Système Solaire ou exposant des techniques utilisées en planétologie dynamique (cf refs.). La 18^e École de Goutelas s'est tenue du 2 au 7 mai 1994, et fut dévolue à l'étude de ces phénomènes d'impact, et en particulier à ceux ayant affecté notre planète, la Terre. Ce livre en est issu, et les chapitres actualisés.

Enfin, nous souhaitons remercier Monique Fulconis, qui sut assurer le secrétariat et régler tous les détails matériels avec efficacité et gentillesse.

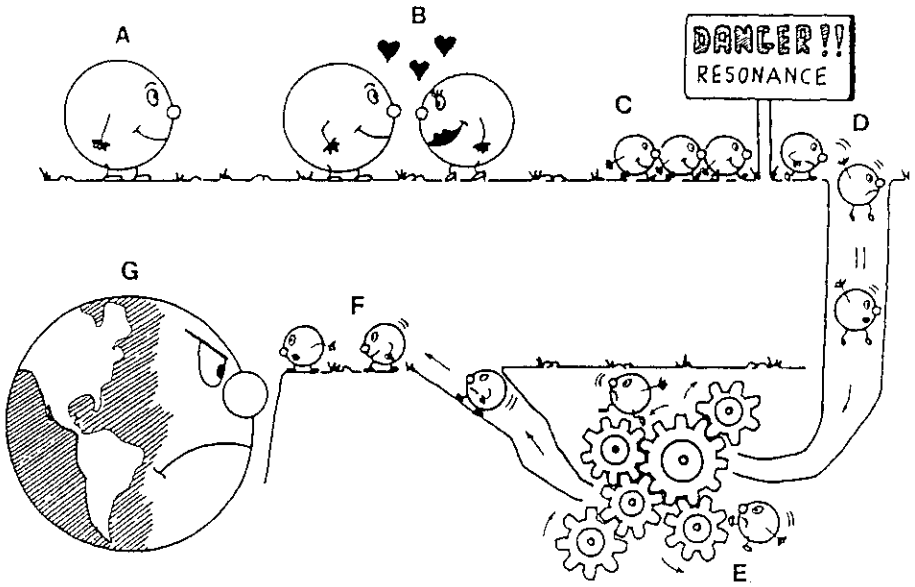

Fig. 1. Vincenzo Zappala, de l'Observatoire de Turin, illustre par ce dessin comment des fragments (C) issus d'une collision entre astéroïdes (A et B) peuvent être "piégés" dans une résonance (D) puis, par un mécanisme complexe (E), transférés dans les régions du Système Solaire interne (F) où ils risquent de rencontrer la Terre (G).
Vincenzo Zappala, from Turin Observatory, shows by this picture how fragments (C) produced during a catastrophic collision between asteroids (A and B) may be trapped in a resonance (D) then, by a complex mecanism (E), transfered in the inner regions of the Solar System (F), where there is a danger of collision with the Earth (G).

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