# Reminiscences of the early days of quasicrystals

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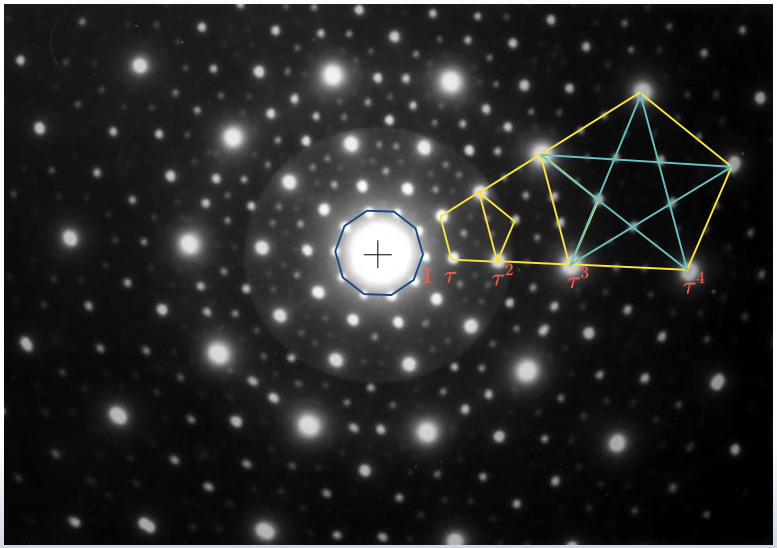
# Crossing the bridge

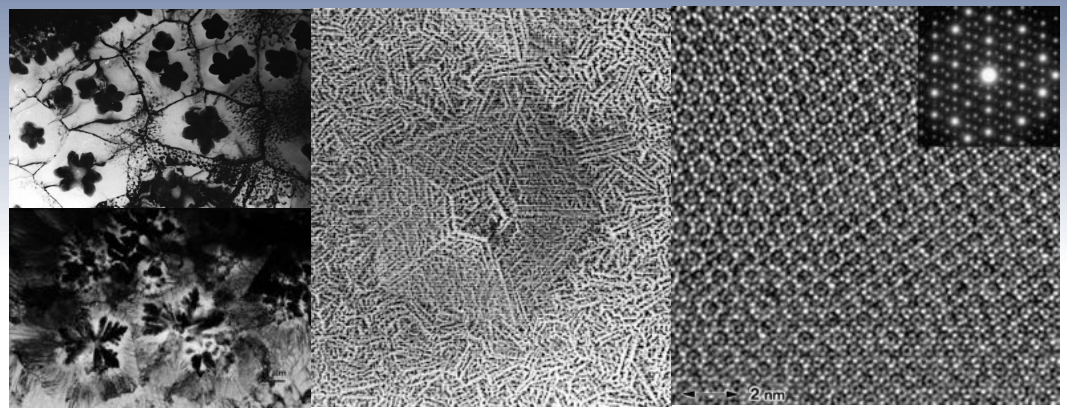
From Metallurgy to Mathematics



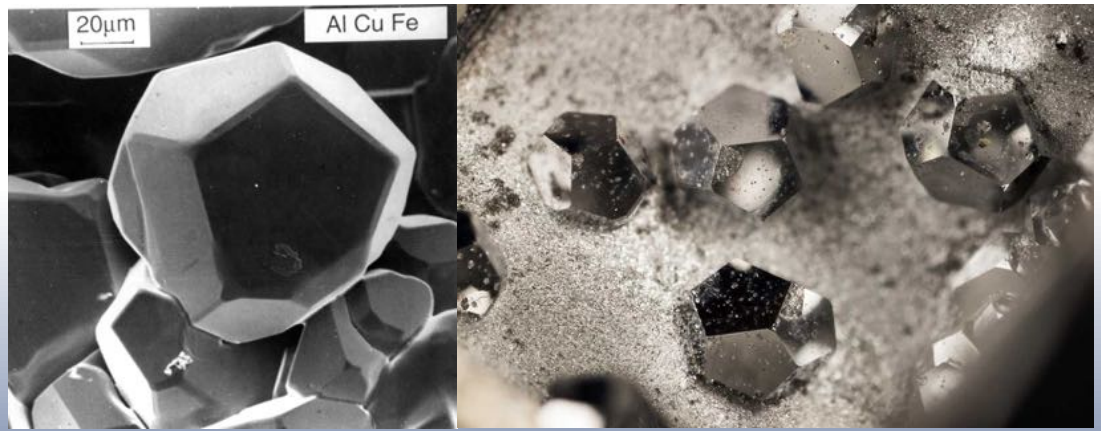

$\Longleftrightarrow$ $\Lambda - \Lambda \subseteq \Lambda + F$

*D. Shechtman* *Y. Meyer*

# The experiments



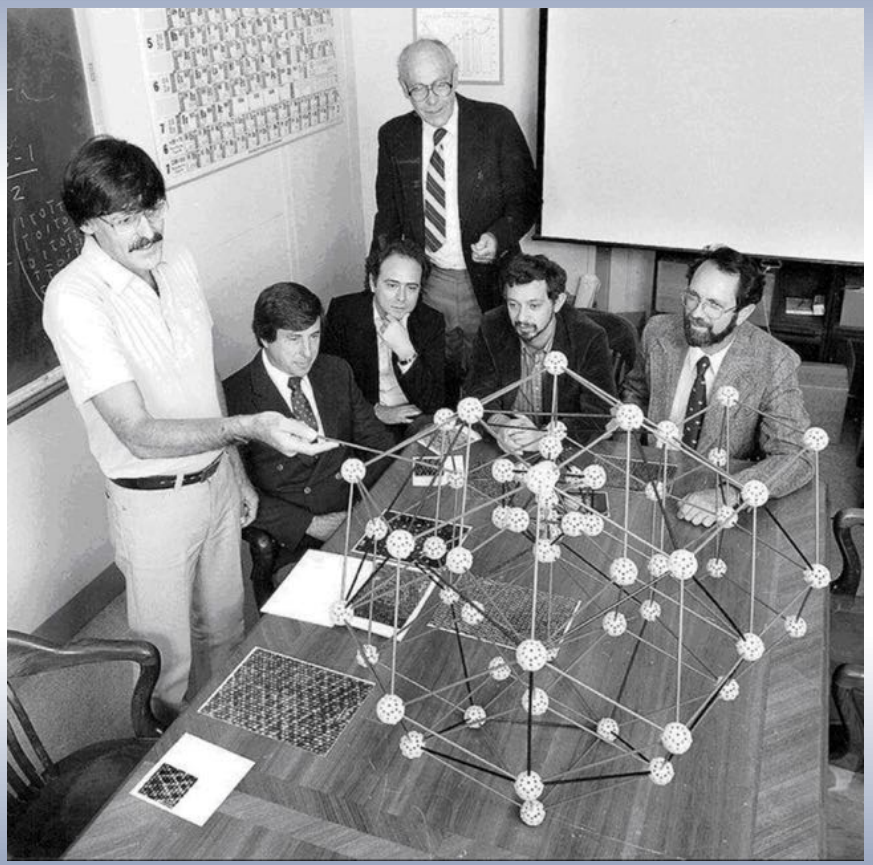

AlMn AlMnSi AlPdMn




AlCuFe MgZnDy

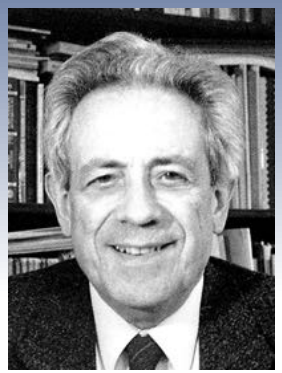
# The experiments

John Cahn's group on quasicrystals at NIST



March 1985 in collaboration with CECM

# The IHES Workshop



January 1985

Louis Michel and Marjorie Senechal

**Report on the *IHES* Workshop on Mathematical Crystallography**

**by Marjorie Senechal**

A month-long international workshop on mathematical crystallography was held at the *Institut des Hautes Etudes Scientifiques* (IHES), in Bures-sur-Yvette, France, in January 1985. Organized by Professor Louis Michel, a physicist and permanent member of the Institute, the purpose of the workshop was to bring together mathematicians, physicists, and crystallographers to discuss some of the fundamental problems in the field. The speakers, who came from seven countries, stayed at the Institute for varying lengths of time, from five days to the entire month; the other participants in the workshop — which was open to everyone — were faculty members of nearby universities and institutes. There were two or three lectures on one day each week (January 4, 10, 17, 24, 31); during the rest of the time the participants discussed problems, did their own research, and visited nearby Paris. The atmosphere was informal and the discussions very stimulating; it was a workshop that really was one.

Michel Duneau

André Katz

The first lectures, on January 4, were introductory: Marjorie Senechal (USA) opened the workshop with an historical-expository talk, *Introduction to Mathematical Crystallography*; she was followed by Louis Michel, who spoke on *Crystallography in* n *Dimensions*. Geoffrey Shephard (UK) was the first speaker on January 10, with a lecture on *The Classification of Patterns with Respect to Symmetry*. The next speaker was Hans Raszillier (FRG), who spoke on *Crystallography in Quantum Mechanical Spectral Problems*. The third lecture was also by Shephard: *The Aperiodic Tilings of Penrose and Amman*. The three lectures on January 17 were *Laminated Lattices* by John H. Conway (UK), *Modulated Crystals* by Aloysio Janner (Netherlands) and *Conjugation Classes of Crystallographic Groups* by Jan Mozrzymas (Poland). Conway also gave an unscheduled lecture the next day on aperiodic tilings. On January 24, Peter Engel (Switzerland) spoke twice, first *On the Uniqueness of Crystal Structure Analysis* and later on *Geometrical Crystallography*. In between these talks, Denis Gratias (France) talked about the *Discovery of Quasi-Crystals with Icosahedral Symmetry*. (Two of the three co-discoverers, Daniel Schectman (Israel) and J.W. Cahn (USA) were also present.) The final session of the workshop, January 31, included a lecture by André Katz (France) on his work with Michel Duneau, *Étude et généralisation des pavages de Penrose*, a lecture on *Bravais Lattices of Coxeter Groups* by Pierre Cartier (France) and a discussion of the lectures of the month and open problems, led by Louis Michel.

1985 — *D. Shechtman, J.W. Cahn & D. Gratias; V. Elser: Indexation*

1985 — *R. Portier, S Hiraga, first HREM picture of icosahedral phases*
*M. Audier, P. Guyot; V. Elser, C. Henley; first atomic description*

1985 — *A. Katz & M. Duneau; V. Elser; P. Kalugin, A. Kitaev &*
*L. Levitov: The cut and project method*

1984 — *D. Levine & P. Steinhardt PRL (Nov 2th)*

1984 — ***D. Shechtman, I. Blech, D. Gratias & J.W. Cahn PRL (Oct 7th)***
***D. Shechtman, I. Blech, Trans AIME (Oct 2th)***

1984 — *P. Kramer & R. Neri Acta Cryst. A*

***D. Shechtman discovery of quasicrystals (April 8th)*** — 1982

*A.L. Mackay Crystallography and the Penrose pattern*
*A.L. Mackay de Nive Quinquangula* — 1981

1981 — *De Bruijn Penrose Algebraic theory of Penrose patterns*

*A. Janner & T. Janssen: Superspace description* — 1977

1974 — *R. Penrose Aperiodic tilings*

*P.M. De Wolff Incommensurate structures* — 1974

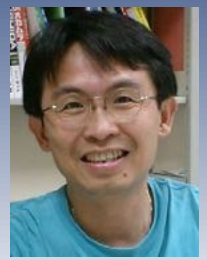
1970-72 — *Y. Meyer Number theory and harmonic analysis*

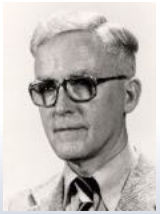
*K. H. Hardy & J. M. Silcock Al6CuLi3* — 1955

*A. J. Bradley & H. J. Goldschmidt AlCuFe* — 1939

1924-26 — *H. Bohr Acta Math. Almost periodic functions*

1904 — *E. Esclangon Thèse Paris Les fonctions quasi-périodiques*



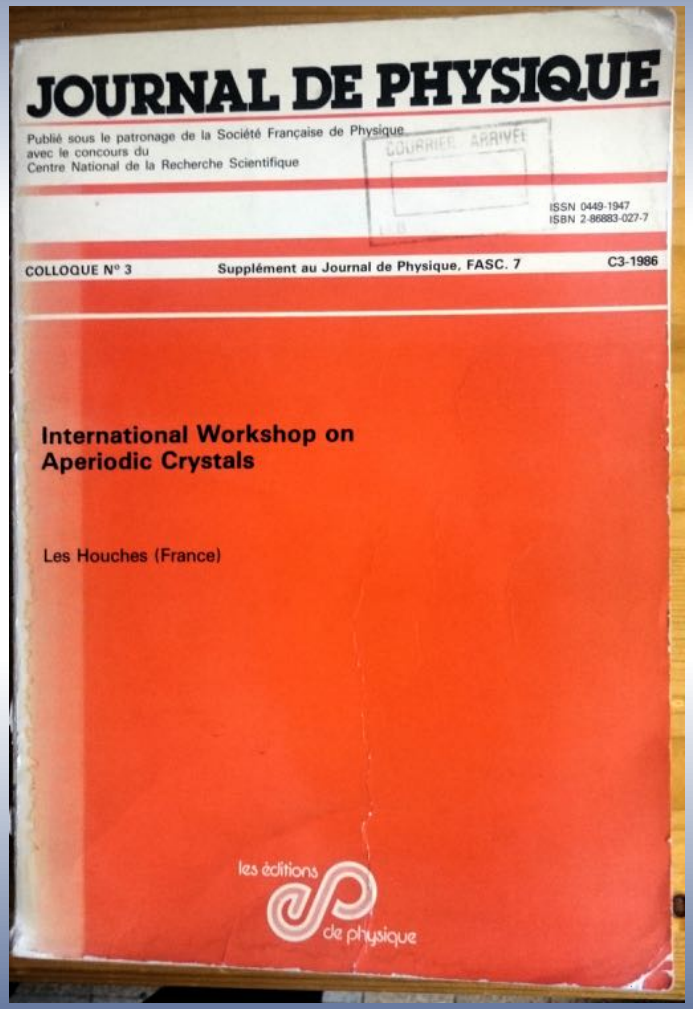


# Quasicrystals

- one discoverer ;
- many inventors ;

# Aperiodic crystals

First international Workshop in Les Houches march 1986



# Quasicrystals

aperiodic or superperiodic crystals ?

## A possible (sub)classification

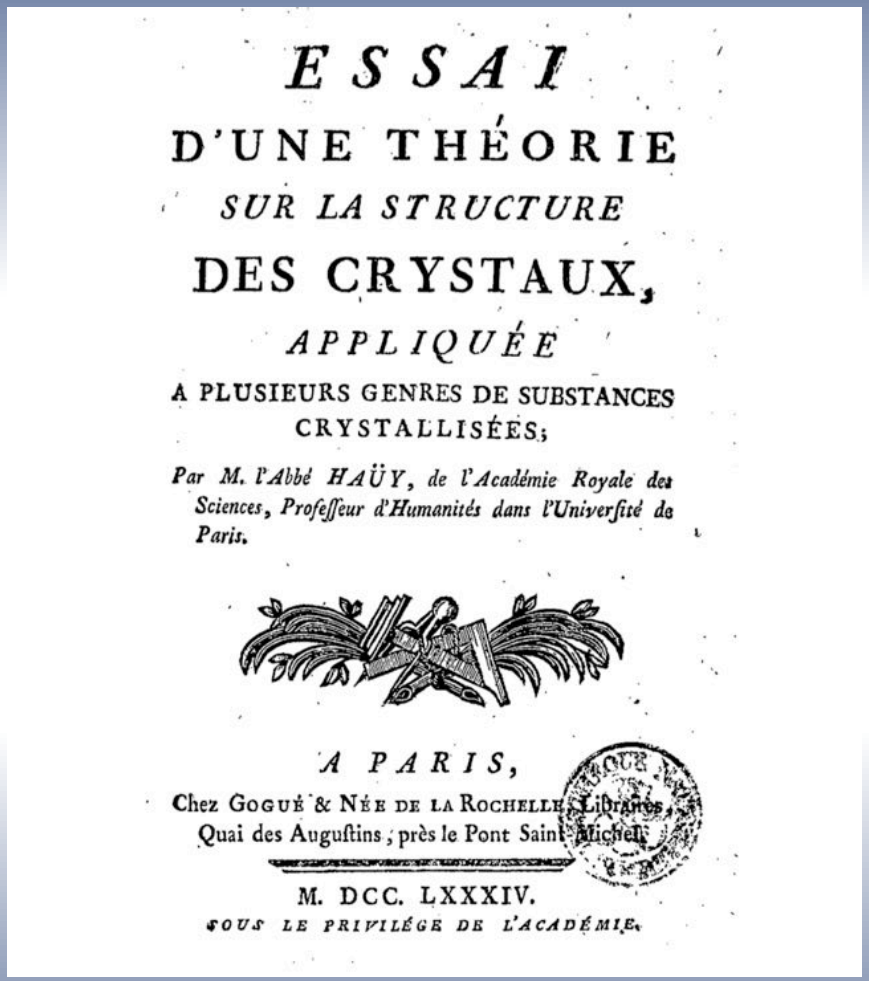
- solids exhibiting a pure point diffraction pattern distributed on a $\mathbb{Z}$ -module of rank $N > 3$ could be called superperiodic crystals.

$$\vec{Q} = \sum_{i=1}^{N} n_i \vec{q}_i, n_i \in \mathbb{Z} \quad N > 3$$

  This includes incommensurate phases, composite structures and quasicrystals ; all known ordered solids that carry a number of periods higher than the dimension of the space.

- These phases have the property of being all possibly described by the cut method.

# The ancients and the moderns. . .



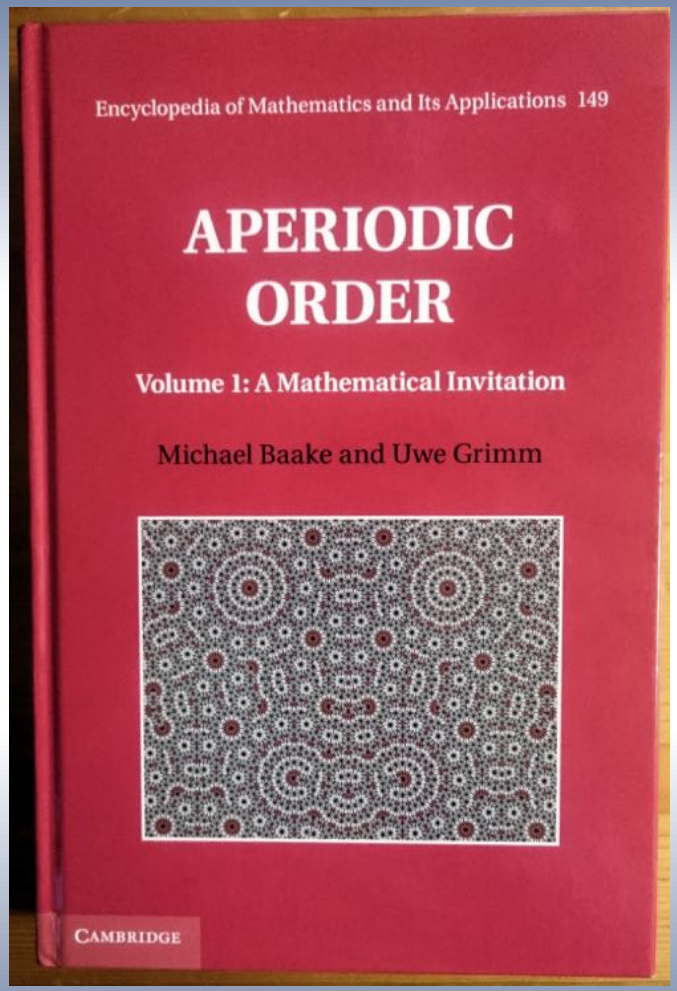
ESSAI
D'UNE THÉORIE
SUR LA STRUCTURE
DES CRYSTAUX,
APPLIQUÉE
A PLUSIEURS GENRES DE SUBSTANCES
CRYSTALLISÉES;

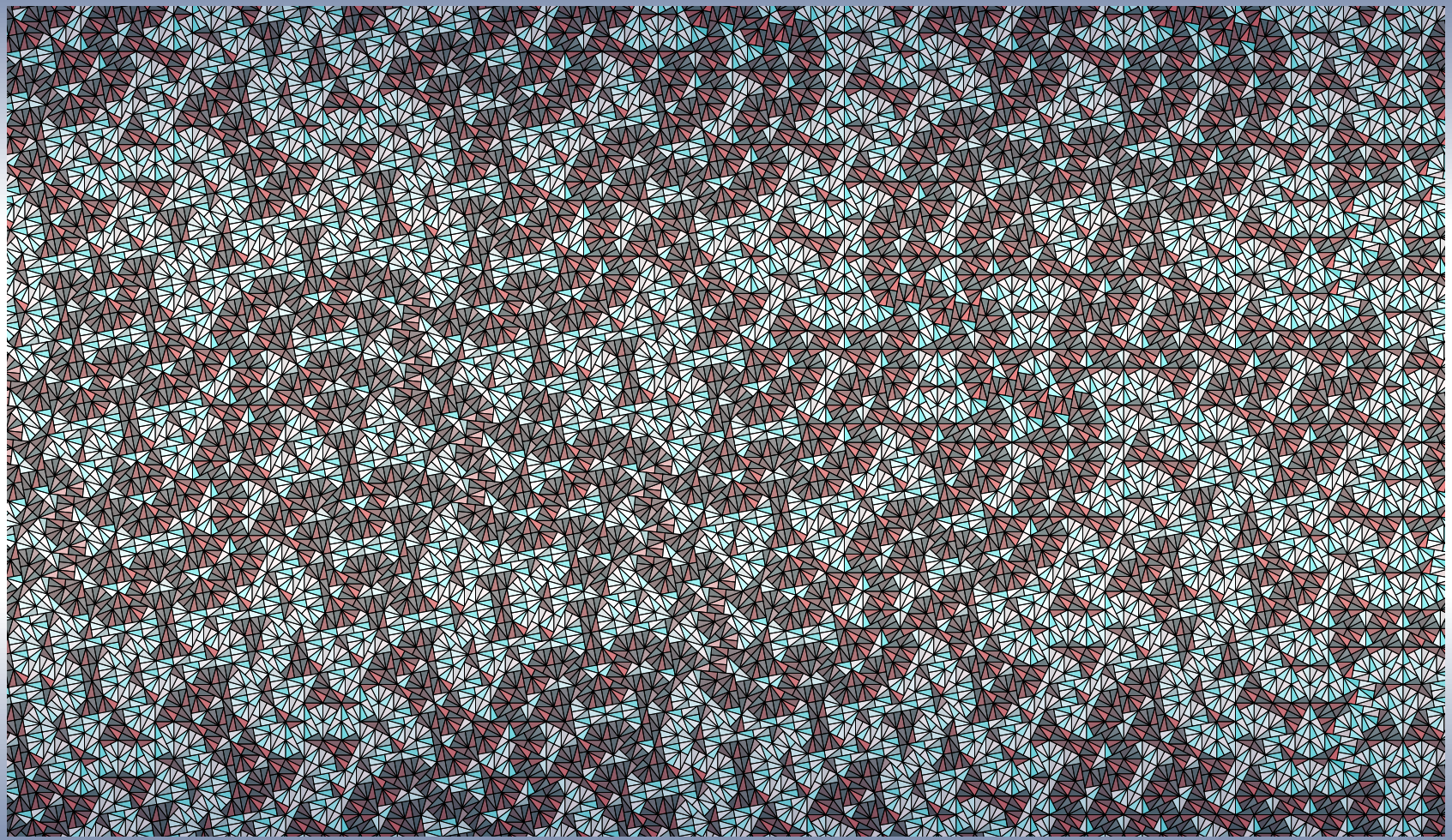
Par M. l'Abbé HAÜY, de l'Académie Royale des Sciences, Professeur d'Humanités dans l'Université de Paris.

A PARIS,
Chez Gogué & Née de la Rochelle, Libraires,
Quai des Augustins, près le Pont Saint-Michel.

M. DCC. LXXXIV.
SOUS LE PRIVILÉGE DE L'ACADÉMIE.

1794




2013

# Next step. . .