Between physics and art: imaging the un-image-able

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Volume **two**

Supporting material

Contents

Introduction

In support of the examination of my art practice as seen in volume one, this document illustrates in more detail the creative journey and underlying method for the production of artworks. A range of examples are presented here, featuring the various stages, from the initial source of inspiration rooted in scientific material, the research involved in exploring colour-form relationships, through to the final piece.

The way each artwork is discussed varies, as different dimensions in the art practice are emphasised: in some instances the visuals play a more central role, almost self-explanatory, revealing how the creative journey develops (pp.18-21), while in others, additional scientific background is given (p. 23). Some artworks are also accompanied by quotes from the scientists whose research inspired the artistic response. Others include my own comments, where I discuss particular aspects that I encountered during the process of visual construction.

Most of this selection presents work from the period between 2008 and 2012, where my practice was particularly concerned with the careful negotiation of scientific notions / fragments from its source and how they may be manipulated to become new imagery. The last piece featured in this document (pp. 24-25), reflects on a new direction and a more experimental approach, extending into a different form of interaction with scientific notions. This series, entitled Visual Rhythmetics, aims to capture how my art practice is growing and evolving from its more established body of work. This also resonates with the analysis of the practice provided in volume one, chapter 3, where I indicate how its underlying method is gradually developing.

Nanoscience series

Series of artworks comissioned in 2008 for display at the Centre for Nanoscience and Quantum Information, University of Bristol.

The following artworks (pp. 4-7) refer to a commission for the Centre of Nanoscience and Quantum Information (University of Bristol) – a leading-edge international research centre. The project was led by Professor Mervyn Miles, Department of Physics at the university, and financially supported by the South West of England Regional Development Agency. Although the brief was left open, the commission required the creation of a series of work exploring the themes of nanoscience, so as to relate to the scientific work taking place at the centre.

As I started to research the topic, what became of particular interest and fascination to me was less about the applications of nanotechnology and more about the fundamental aspects of scientific research, in particular specialist imagery produced by technology such as scanning probe microscopy, showing complex atomic structures, grids and patterns – pictures that convey intrinsic visual qualities associated with the science they represent, at a scale barely depictable. In this section, I have included a range of examples from the visual investigations I conducted for this project, alongside the source reference from scientific papers. Photographs were taken on site, to evaluate the space for the artworks; these served later to produce photo montages, to visualise the artwork *in situ*, prior to the final setup. Some of these photos have also been included here.

Redacted due to copyright

Figure V2.1: Original figure, from the article: Schricker, A. D., et al 'Electrical transport, Meyer–Neldel rule and oxygen sensitivity of Bi_2S_3 nanowires' in *Nanotechnology* vol. 16, no. 7 (2005), S508–S513, p. S510.

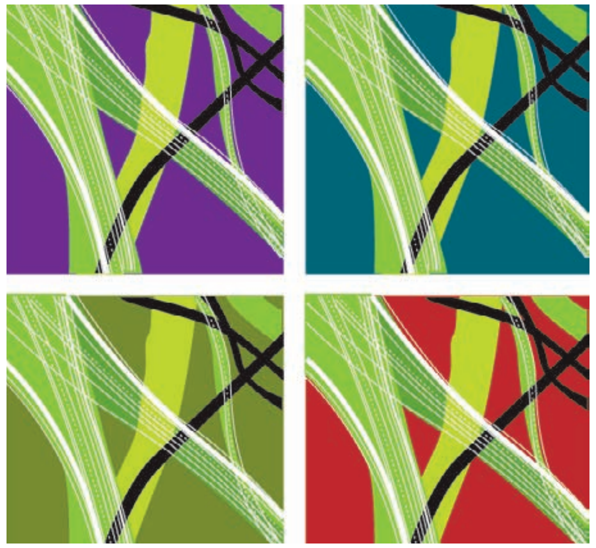

Figure V2.2: Visual research, exploring a range of colour options after the structural pattern has been redrawn.

Figure V2.1* (a transmission electron microscope image of nanowires), has served as a trigger for the exploration of its patterns and lines of networks. After capturing these shapes in redrawing the figure, I started to explore colour combinations, as shown in figure V2.2. As I considered the colours, I found that this visual seems particularly suited to a range of colour possibilities, working equally well with warm reds and purples or colder shades of green. In this particular example, the visual expresses organic shapes and a "freer", more unbalanced arrangement of forms, in contrast to the dominant approach in my work, where I often tend to focus on geometric and symmetrical arrangements.

* Note: these artworks formed part of the research for the project; however, they were not selected for the final commission.

Redacted due to copyright

Figure V2.3: Original figure, from the article: Stoica, T., et al 'Two-dimensional arrays of self-organized Ge islands obtained by chemical vapor deposition on pre-patterned silicon substrates' in *Nanotechnology* vol. 18, no. 45 (2007), 455307, p 5.

In this example, I was particularly interested in extracting remnants suggested in the original figures (V2.3) and interpreting them to become a geometrical composition. Although the source reference shows irregular shapes, I deviated from it, to transform the visual research into a symmetrical pattern, as shown in figure V2.4*.

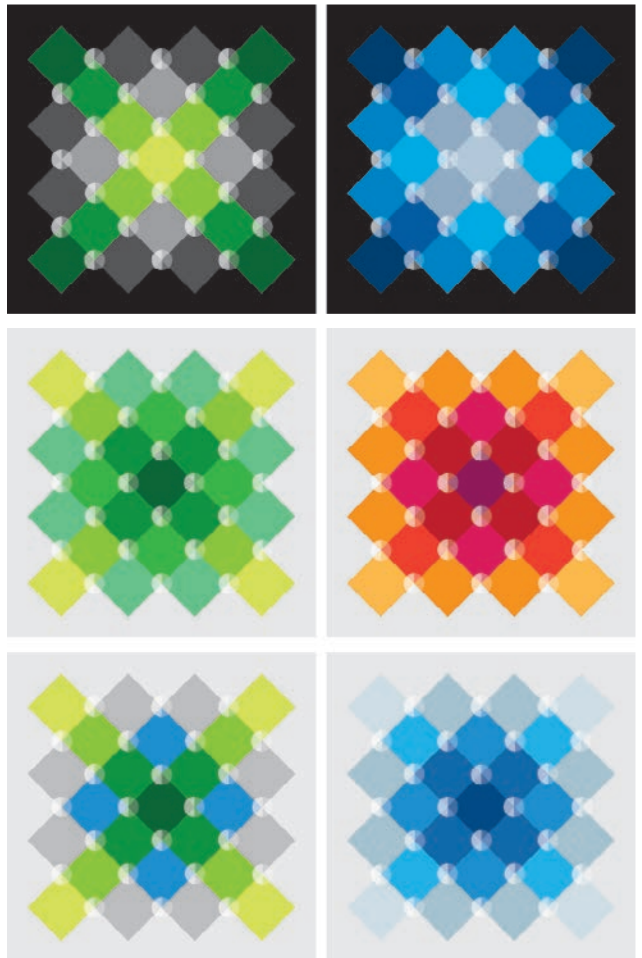

Figure V2.4: Visual research on pattern arrangement and geometrical construction. This set also includes the research on possible colour variations.

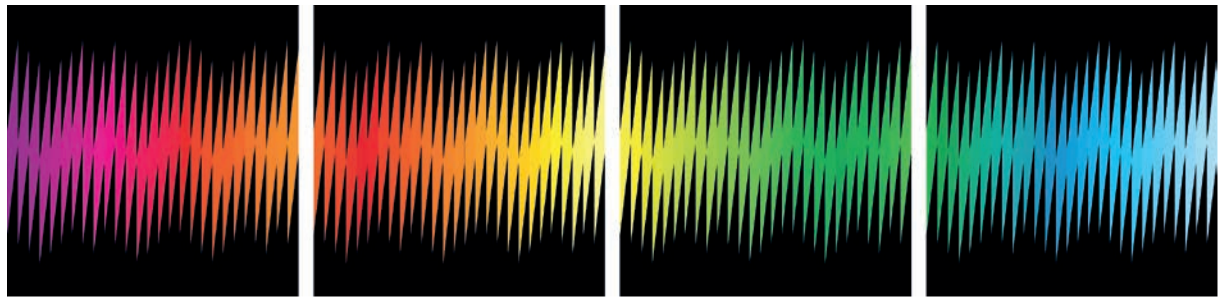

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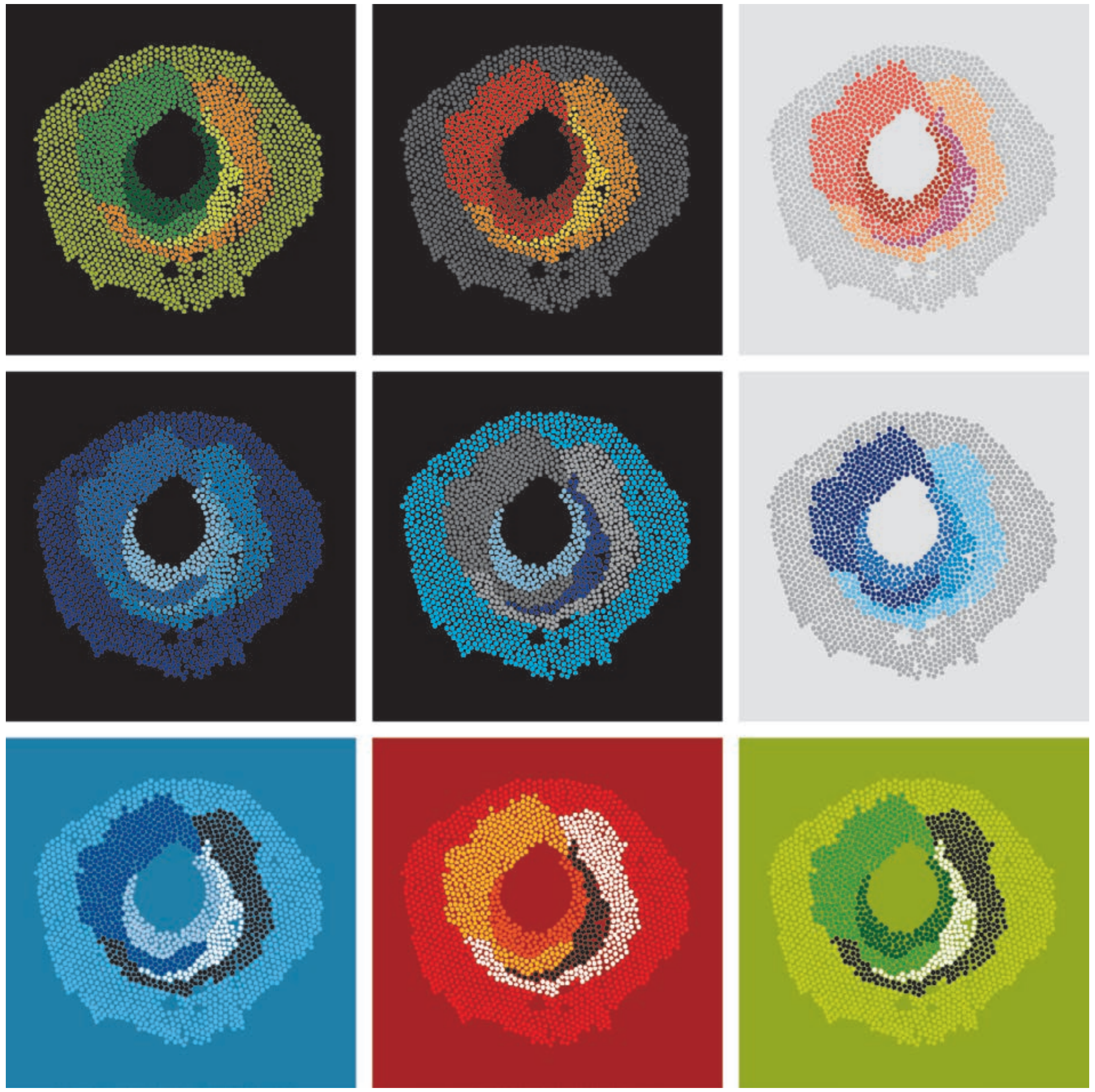
Figure V2.5: Original figure.

Figure V2.6: Artwork simulated *in situ* (photo montage).

Figure V2.7 (above): Final artwork, *Charge Oscillations* (2008), tetraptych, archival pigment print sealed and mounted into 2 mm aluminium, 900 × 900 mm each, edition of 4.

An artistic interpretation showing a numerical simulation of charge oscillations in a silicon double-dot device system. The simulation strongly correlates with experimental values of the low temperature transport properties of the double-dot system. Inspired by a figure in Mitic, M., et al 'Bias spectroscopy and simultaneous single-electron transistor charge state detection of Si:P double dots' in *Nanotechnology* vol. 19, no. 26 (2008), 265201, p. 5.



Redacted due to copyright

Figure V2.8: Original figure.

Figure V2.9: Artwork simulated *in situ* (photo montage).

Figure V2.10 (above): Set of colour research for the artwork *Nanoparticle Gold Ring* (2008). Final artwork, as shown in figure V2.9: archival pigment print, 800 × 800 mm, edition of 4.

An artistic interpretation of an electron microscopy image showing a ring structure of gold nanoparticles. The average diameter of the nanoparticles is 10 nm. In this instance the gap at the centre of the ring structure is formed by slow evaporation of the solvent media. Inspired by a figure in Pyrpassopoulos, S., et al 'Synthesis and self-organization of Au nanoparticles' in *Nanotechnology* vol. 18, no. 48 (2007), 485604, p. 3.

Between physics and art: supporting material

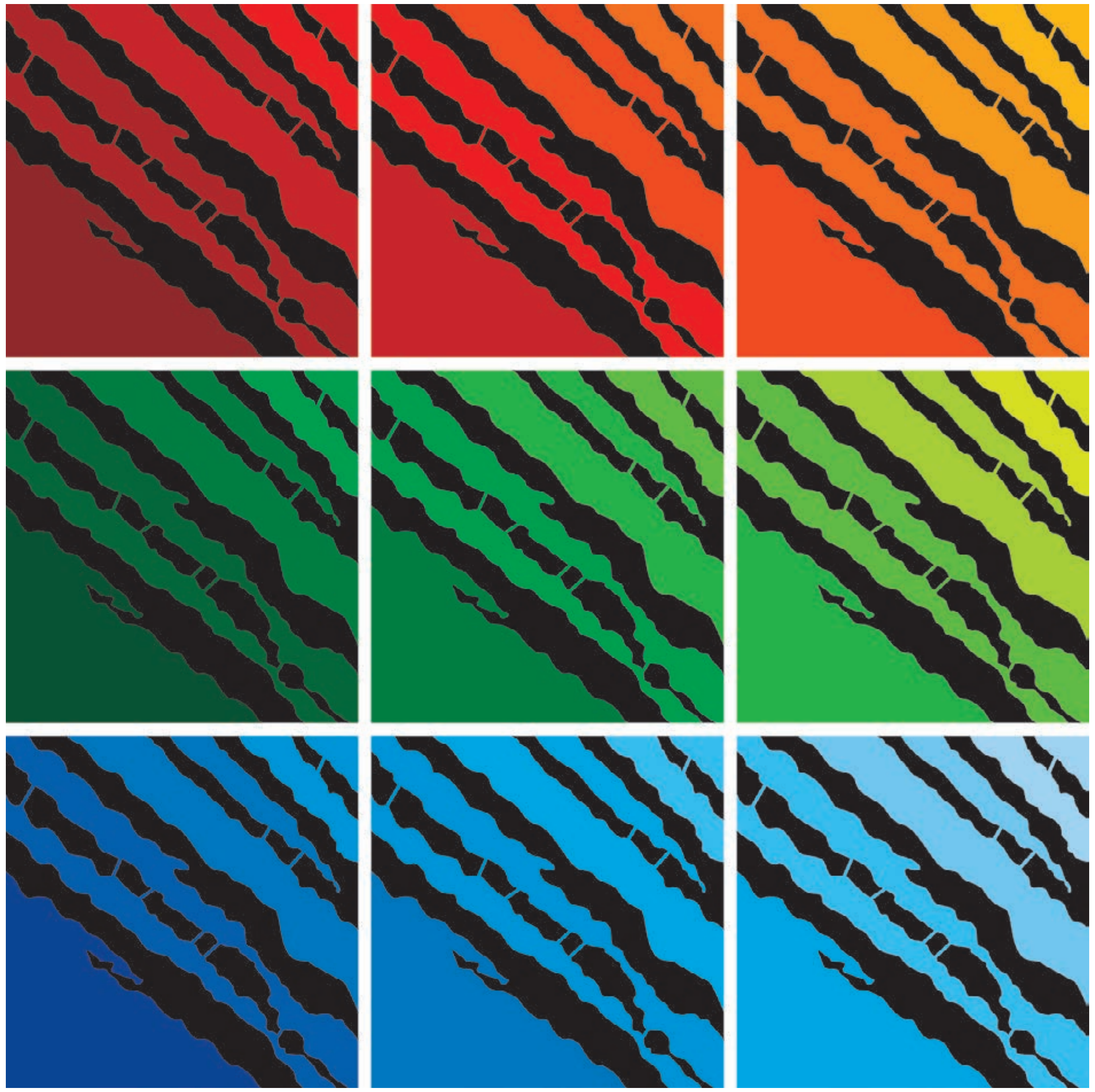


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Figure V2.11: Original figure.

Figure V2.12: Artwork simulated *in situ* (photo montage).

Figure V2.13 (above): Final artwork, *DNA Bridges* (2008), archival pigment print, 800 × 800 mm, edition of 4.

An artistic interpretation of an atomic force microscope image of DNA molecules deposited onto the mineral chlorite. Some DNA molecules are observed to stretch and bridge across and over the mica-like regions of the mineral. Inspired by a figure in Antognozzi, M., et al 'A chlorite mineral surface actively drives the deposition of DNA molecules in stretched conformations' in *Nanotechnology* vol. 17, no. 15 (2006), 3897-3902, p. 3900.

Quantum Obstacle

Redacted due to copyright

Figure V2.14: Sample pages from the article: Schomerus, H., et al 'Multiple-path interferometer with a single quantum obstacle' in *Europhysics Letters* vol. 5, no. 57 (2002), pp. 651-657.

Redacted due to copyright

Figure V2.15: Original figure.

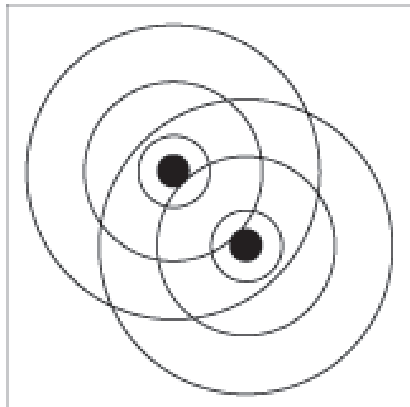

Figure V2.16: Graph redrawn as an outline.

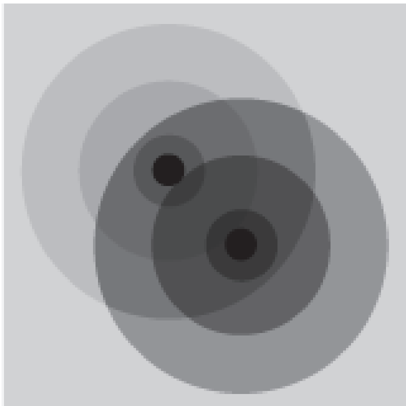

Figure V2.17: Graph redrawn in grayscale.

Selecting figure 1 from the above article, I identified from its inherent visual qualities the possibility for further exploration into formal and structural aspects. As I redrew the figure, I removed the grid to concentrate on the study of the arrangement of circular shapes. The figure is first reproduced as an outlined version (figure V2.16), then in grayscale (figure V2.17), as each surface area is deconstructed as a single "unit", prior to the colour study.

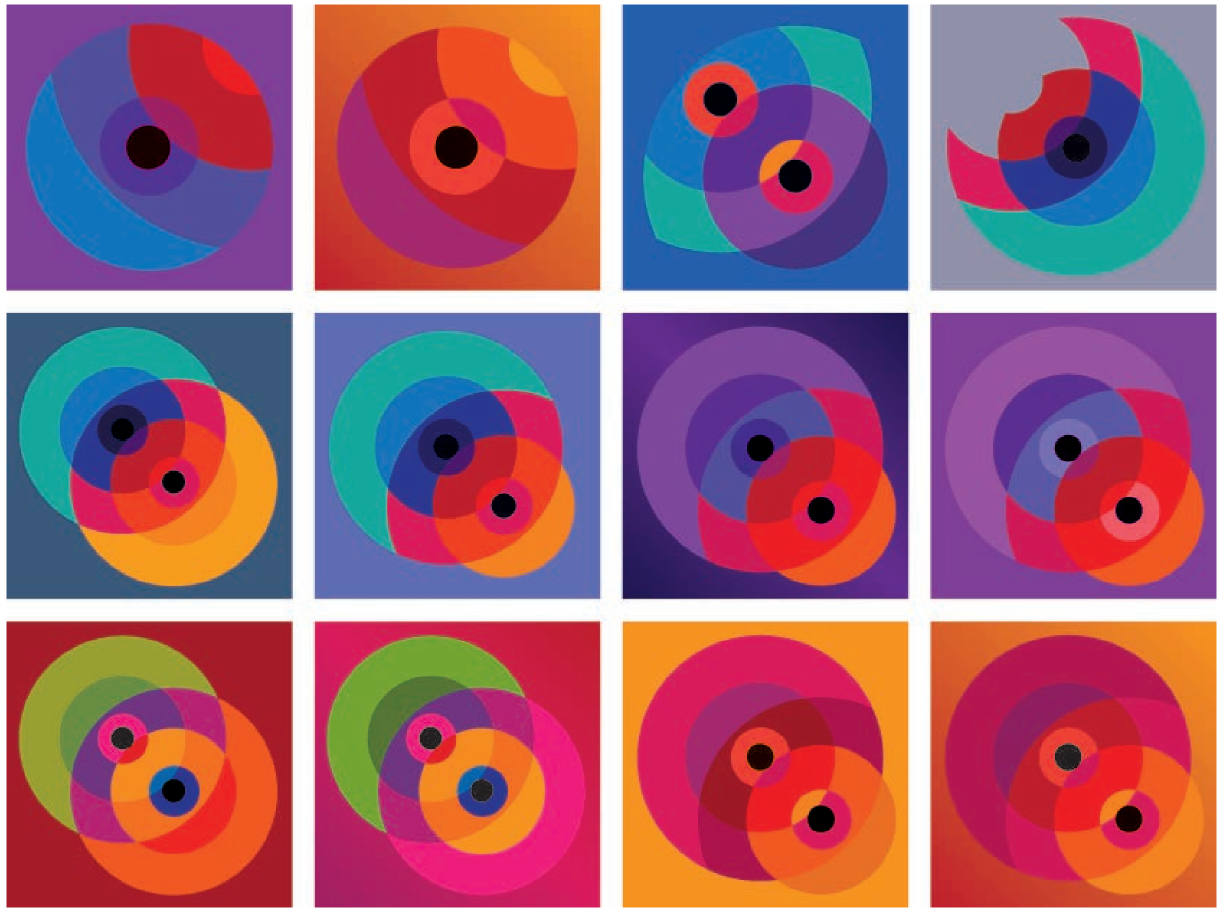

Figure V2.18: Example of form and colour research, investigating a range of possible combinations.

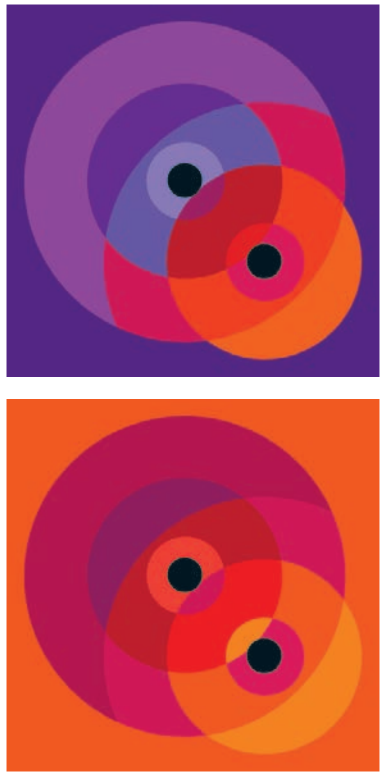

Figure V2.19: Selected versions for final artworks.

An extensive exploration of colours follows (figure V2.18). As I began to research possible combinations, an interesting relationship developed between the various colour gamuts and shapes, and many possibilities started to emerge. My aim here was to try and achieve a strong visual balance, playing on the vibrancy of particular hues against others. Colour choices remain arbitrary – severed from any symbolic values, as I focused on their physical / optical qualities and on their behaviour next to their neighbouring colours, but also their position within the overall composition.

As some stage, I considered breaking down the shapes, and selecting only parts of them, but I soon realised that this strategy fails as the inherent qualities carried by the original version start to disapear (see figure V2.18, top row), so I returned to earlier versions retaining a more complete structure of forms.

As the research process continued, I narrowed down the options to two colour families, an orange and a dark purple version. Here, more subtle refinements were needed, as I explored slight variations in the colour values for each artwork. Figure V2.19 shows two visuals approaching what will serve to become the final artwork.

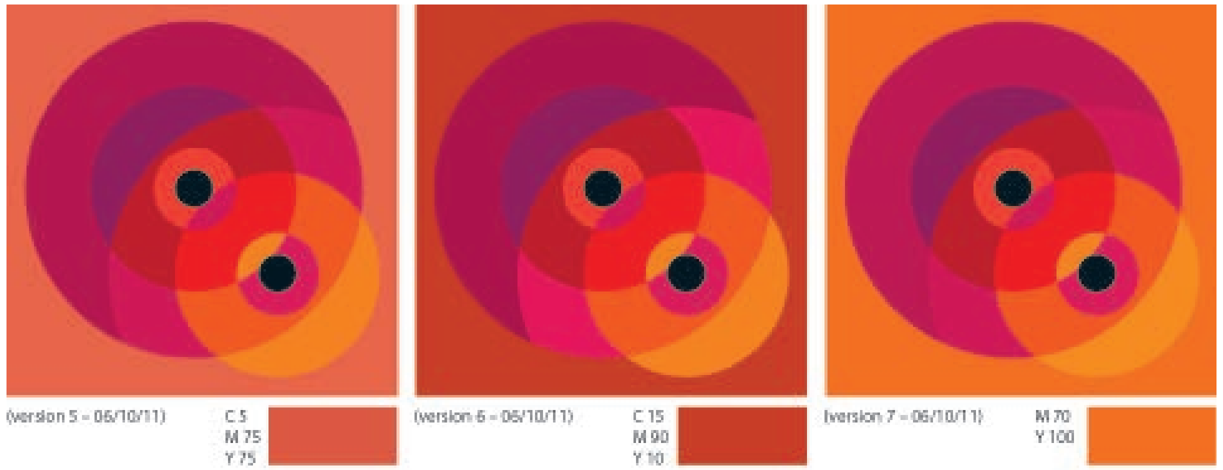

Figure V2.20: Examples of colour tests, numbered, dated and annotated, as to keep a record of the colour variations prior to the final artwork.

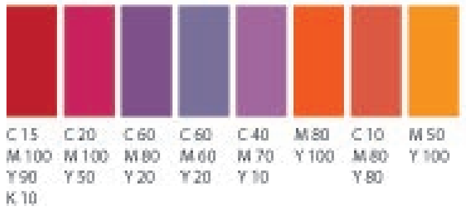

Figure V2.21: Example of colour set in CMYK accompanied by its numerical values.

The preparation of files prior to conduct test prints took place (figure V2.20) with a more refined set of colour families, and variations setup together, to be able to compare between each option. Colour tests are usually numbered and dated and accompanied by the colour references. For instance, subtle variations on the background orange are an important part of the process, and are evaluated at the printing stage for accuracy. CMYK colour value are also recorded, for reference (figure V2.21).

Comments from authors

Once the artwork was finalised (figure V2.22), I sought feedback from the scientists whose work inspired this piece. I contacted both Professors Schomerus and Dalibard, who kindly replied with their thoughts and comments, as shown below. Of special interest here, is how they seemed to understand with remarkable insight the creative process leading to this artwork.

For a physicist, it is a true challenge to graphically capture the quantum phenomenon of wavelike superposition. By adding the dimension of colour, arranged in subtly interweaving segments, Swist has created a piece of art which conveys an ephemeral illusion that actually very well suits the original subject. The quantum world is a bit dreamlike, and so is this artwork.

Professor Henning Schomerus, Department of Physics, Lancaster University

The source material for Frédérique Swist's artwork is a representation of a wave diffused by an atom located at two places simultaneously – an example of the strangeness of the quantum world. It is interesting to see in Swist's first stage of research a detachment from the theme we wished to illustrate, then a closeness which ultimately renders remarkably well the dynamic aspect that we wanted to model. Swist first deconstructs the image to exhibit patterns initially unsuspected. She then proceeds to a reconstruction, a gradual transformation which replaces, or supersedes the continuum intrinsic to the wave that we aimed to describe, and that pushes forward its motion around our 'ghost atom'.

Professor Jean Dalibard, Physics Department, École Normale Supérieure, Paris
(my translation from the French)

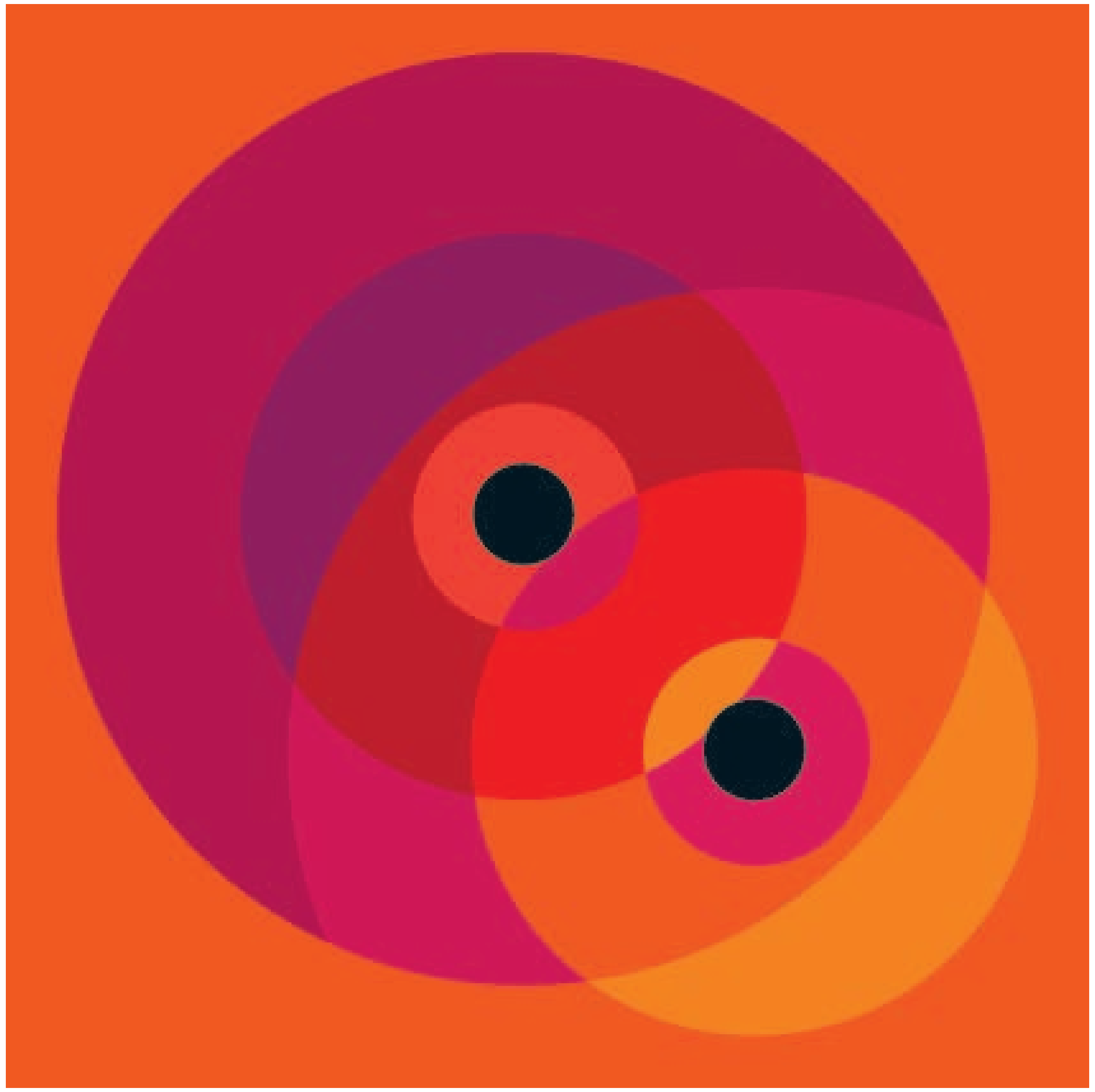

Figure V2.22: Final artwork, *Quantum Obstacle No. 1* (2011), 800 × 800 mm, archival pigment print, limited edition of 25.

Scientific caption to accompany the artwork

An artistic interpretation of the scattering of a particle by a quantum obstacle.

In the final version, I found particularly interesting how a "ripple" effect – yet perfectly composed – is conveyed through the arrangement of circular shaped and accentuated by the positioning of colour gamuts. A lenghty succession of decisions formed part of the creative process, leading to this artwork, which I feel resonates back to the original figure, and yet offers an alternative visual response to it, as it also reveals a hidden visual dynamic – unsuspected in the original, as noted by Professor Dalibard – in this instance, triggered by the deployment of the colour arrangement.

Reaction Dynamics

Redacted due to copyright

Figure V2.23: Sample pages from the article: Ezra, G. S. and Wiggins, S., 'Phase-space geometry and reaction dynamics near index 2 saddles' in *Journal of Physics A: Mathematical and Theoretical* vol. 42, no. 20 (2009), 205101.

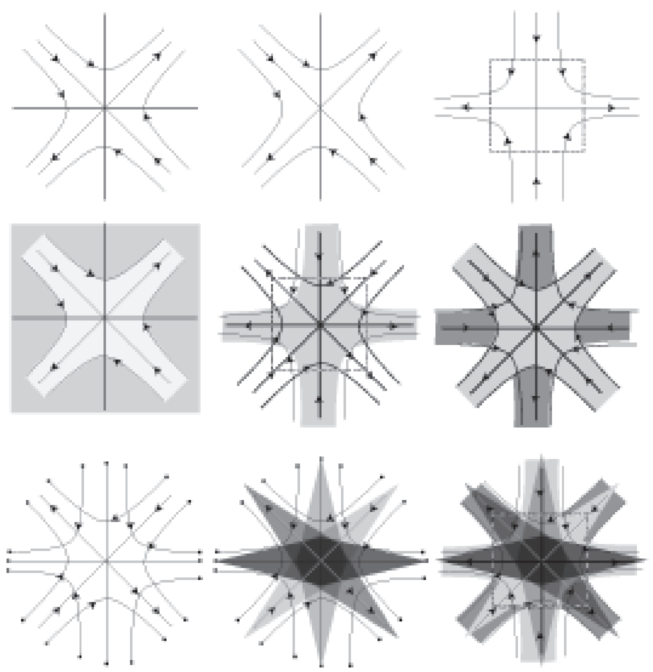

Figure V2.24: Examples from the early visual research, exploring structural and compositional possibilities.

This set (left and above) shows the various stages of exploration, gradually developing as new visual possibilities out of the shapes from the original graphs. These were produced at an early stage in the research, as I focused on investigating formal structures and composition.

Between physics and art: supporting material

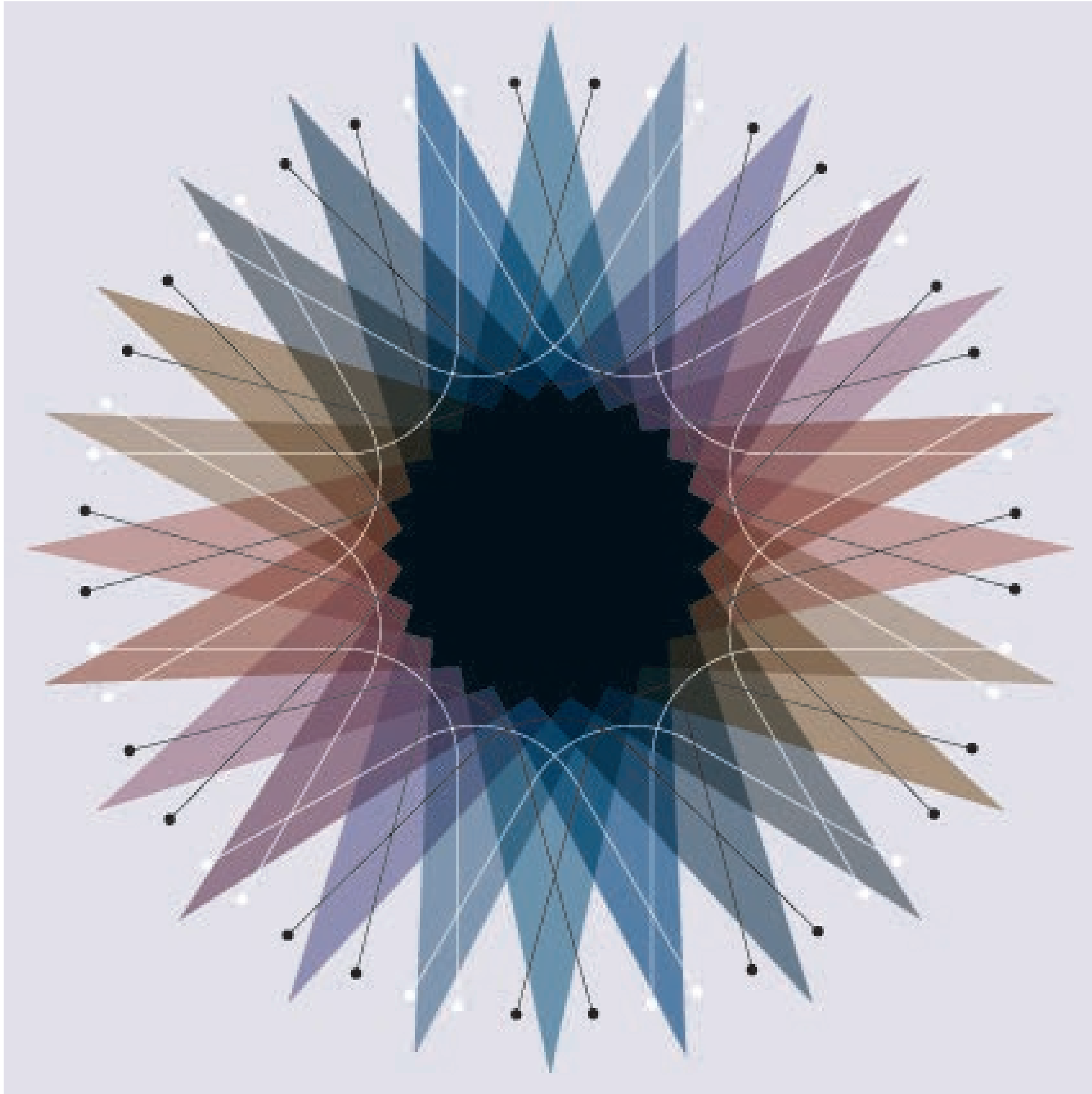

Figure V2.25: Final artwork, *Reaction Dynamics* (2011), 800 × 800 mm, archival pigment print, limited edition of 25.

Scientific caption to accompany the artwork

Artwork inspired by a geometric representation of the phase space of a system with two degrees of freedom.

Comment from the author

The image you have produced is both aesthetically very pleasing and somehow strongly and very correctly suggestive of the index 2 saddle as a nexus for the system dynamics,with trajectories going in different directions to different fates (colors).

Professor Gregory S. Ezra, Department of Chemistry and Chemical Biology, Cornell University

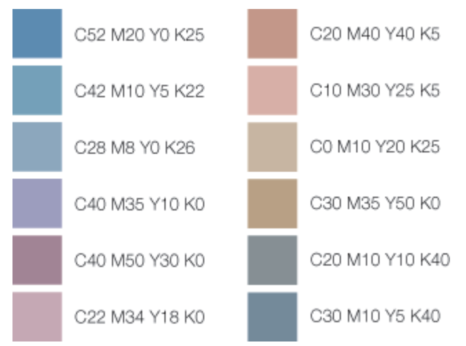

Figure V2.26: Final set of colours, with their CMYK values.

Superoscillations

This artwork was a special commission by IOP Publishing, for the realisation of a bespoke rug, a limited edition fine art print and a series of mug designs for display at its new premises in 2011. The piece is based on a research article by Michael Berry and Mark Dennis, Physics Department, University of Bristol.

Redacted due to copyright

Figure V2.27: Sample pages from the article Berry, M. V. and Dennis, M. R., 'Natural superoscillations in monochromatic waves in D dimensions' in *Journal of Physics A: Mathematical and Theoretical* vol. 42, no. 2 (2009), 022003.

Figure V2.28: Original figure redrawn (left), followed by colour research, exploring different gamut families.

In its original form, figure 1 (in the above article) already expressed intrinsic visual qualities: I was particularly drawn to its arrangement of shapes that shows strong potential for the exploration of a pattern design. As a starting point, figure 1 was redrawn as an outline, and prepared for a colour study. In order to retain a strong degree of accuracy with the original, the image was devided in three layers: firstly a network of lines, secondly well-defined surfaces to carry the colours, and thirdly a background (in this case black) to provide a strong contrast against the chosen colour scheme. A set of colour variations in different families of gamut was subsequently developed, as shown in figure V2.28.

Figure V2.29: Final artwork, *Superoscillations* (2011), 800 × 800 mm, archival pigment print, limited edition of 25.

Scientific caption to accompany the artwork

Superoscillation is an exotic wave-optics phenomenon that could one day find real-world applications in nanoscience and technology – for example, in ultrahigh-resolution microscopy systems and optical "tweezers" used for the study and manipulation of nanoparticles. In this depiction of wave interference, the wavefronts (crests and troughs) are represented by white lines; the black region is where the total wave is oscillating faster (superoscillation) than any of its constituent plane waves.

Colour research prior to production

Figure V2.30: Photographs of the process of colour selection for a bespoke rug, using wool colour swatches provided by the supplier, and mock-ups for the mug designs.

Between physics and art: supporting material

Final artwork *in situ*

Figure V2.31: The final artwork was produced as a 3 × 3 metre rug, and is shown here *in situ* at the IOP Publishing new offices (2011).

Comments from authors

Frédérique Swist has subtly re-rendered our picture of overlapping waves. The wavefronts are highlighted in white over the superoscillatory regions which are marked out in black, and with sober colours indicating the regions where superoscillation does not occur. This makes an attractive image while in no way compromising its scientific content.

Professor Sir Michael Berry,
Physics Department, University of Bristol

Fred Swist's reimagining turns our greyscale representation of subtle, rapid oscillations of random wave patterns into a piece of art in its own right. To me, the tension between the delicate colours echoes the interference between the different waves in the picture.

Mark Dennis,
Physics Department, University of Bristol

Figure V2.32: Packshot presenting the mug designs. Accompanying cards were also produced featuring the scientific caption and reference to the original article.

Cloaking

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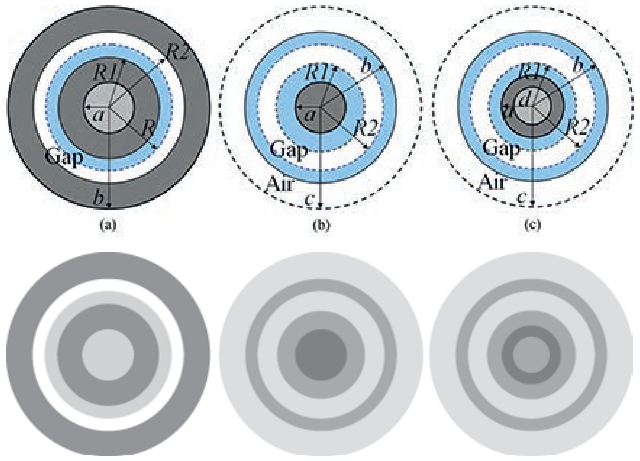
Figure V2.33: Sample pages from the article: Luo, Y., et al 'Cloaks with multiple invisible regions' in *Journal of Optics* vol. 13, no. 1 (2011), 015105.



The initial stage in the research is the redrawing of the original figure, tracing the exact shape and proportion to retain the number of individual elements / internal components, their position in relation to one another, and their proportion. The new figure can then serve as a blueprint for the next stage in the visual research. Here, black and white are employed as neutral non-colours, to form the basis from which I can build a colour family.

Figure V2.34 (left): Original set of figures, redrawn to serve as the basis for the colour study and compositional structure.

The basic blueprint having been established, a move from three elements to a grid of nine was decided, to form the compositional foundation for the artwork. The colour research can now begin. Two main activities / parameters lead the research: firstly, a colour family needs to be defined; secondly, a visual rhythm in response to the shapes and their position within the broader grid. As shown p. 19, a range of colour palettes are explored, and tested in print (p. 20); each sample is numbered and dated to keep track of the variations and to allow me to revisit them at a later stage, for possible refinement.

Between physics and art: supporting material

Figure V2.35: Example of visual research and exploration into colour families and their position within the structure for the artwork.

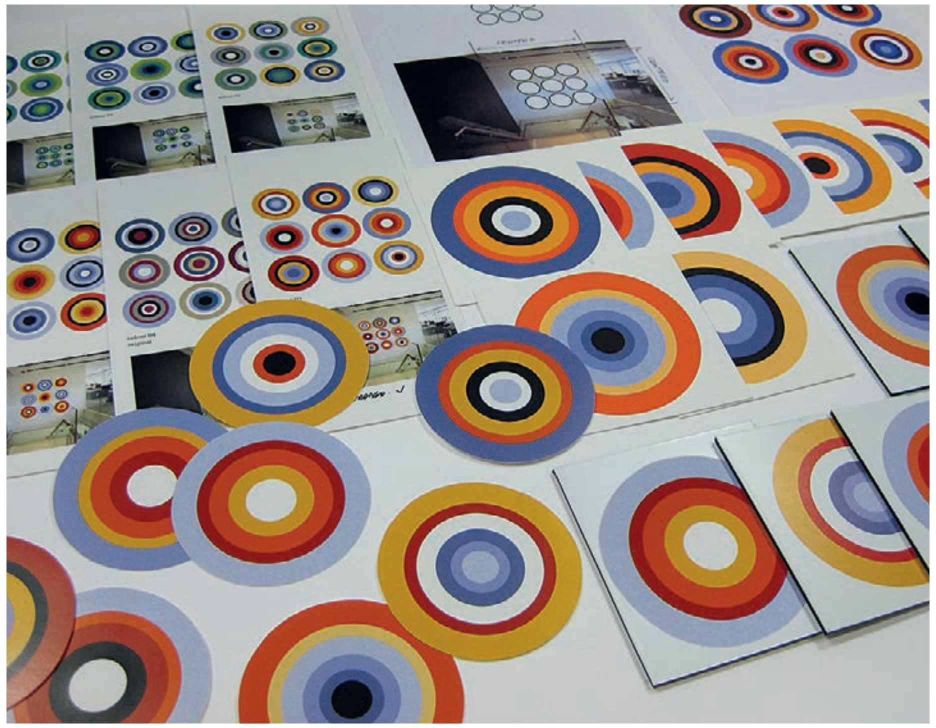


Figure V2.35: Development stage, with the production of reduced-size test prints.

Test prints

Subsequent to the extensive colour research as seen p. 19, a large set of test prints and small-size pieces were produced, serving for further study and refinement, prior to the production of the large-scale final artwork, as shown below.

Figure V2.36: Final artwork, on display at IOP Publishing, Bristol office.

Artwork *in situ*

The final visual was printed directly on Dibond®, a material made of thin composite aluminium sheets. In this instance they were pre-cut into circles of 700 mm diameter, then printed and mounted with sub-frames. The artwork was then displayed as a set of nine circles, each individually hanged, at IOP Publishing, Bristol office (figure V2.36).

Between physics and art: supporting material

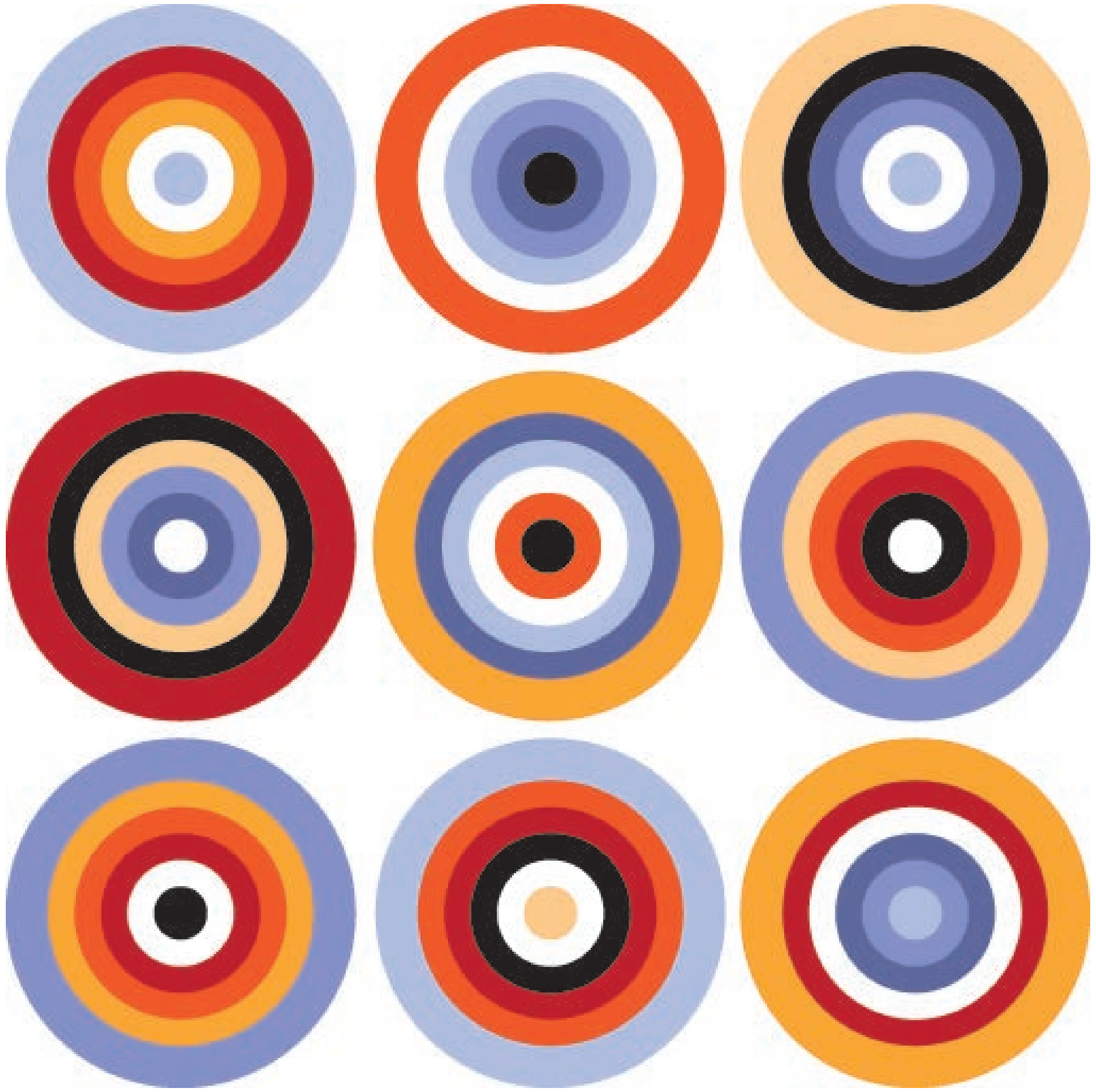


Figure V2.37: Final artwork, *Cloaking* (2012), nine-piece set, 700 × 700 mm each, printed and mounted on Dibond®.

Scientific caption to accompany the artwork

An artistic interpretation of a schematic diagram representing a new cylindrical cloak with an additional exterior invisible region, which allows a concealed object in this zone to receive and transmit signals whilst remaining hidden.

Phase Space

This artwork was a special commission for Professor Jon Keating, outgoing editor-in-chief of the IOP title *Nonlinearity*. The artwork is based on his research published in the journal, and involved working closely with the publisher.

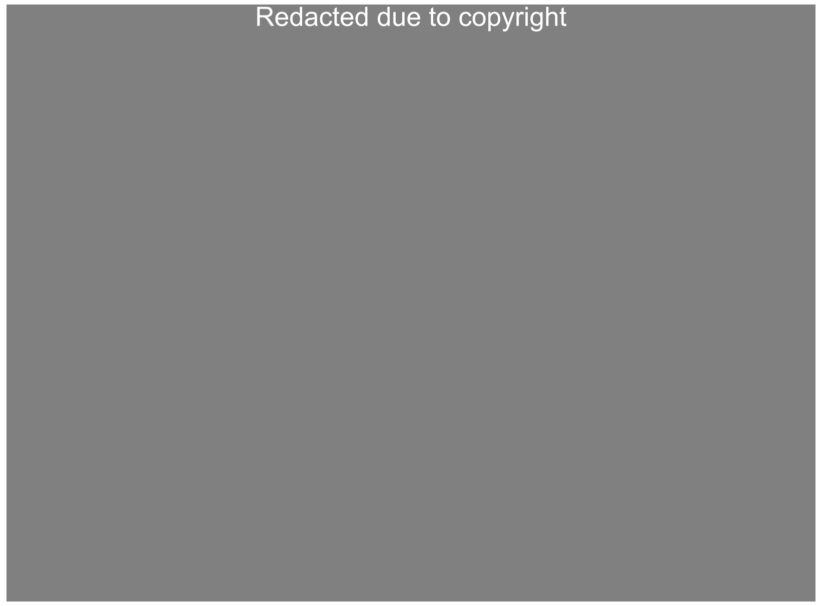


Figure V2.38: Sample pages from the article: Hannay, H., et al 'Optical realization of the baker's transformation' in *Nonlinearity* vol. 7, no. 5 (1994), 1327–1342.

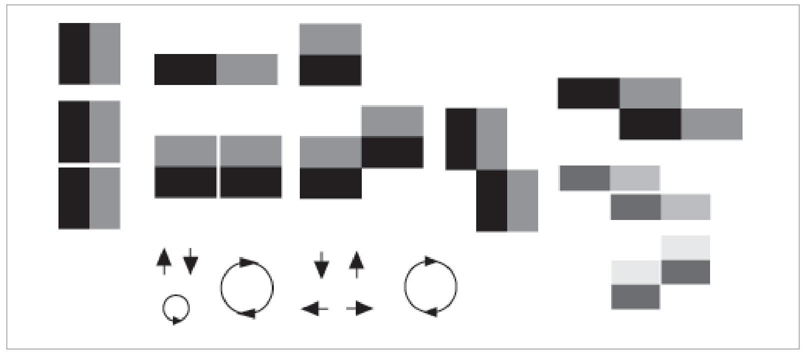


Figure V2.39: Above, early research of forms and composition for *Phase Space*.

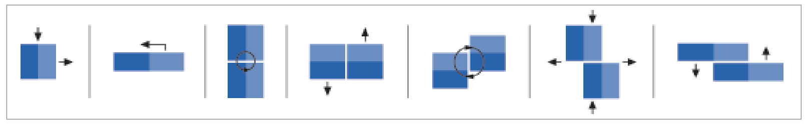


Figure V2.40: Complete set of units, redrawn from the original article, to be part of the final composition.

From the outset the article presented a challenge, as it contained very few graphics. Only figures 1 to 3 in the article could be considered as a possible starting point for further visual exploration.

The initial work focused on redrawing the full set of "units" from the paper. I retained the two-shade graphics, as they had the potential to carry a colour scheme. After discussing the paper in more detail with the journal's publisher, I decided to redraw the directional and circular arrows, as part of the graphic, to retain crucial fragments from the underlying science that they convey (figure V2.39).

Additional visual research followed, exploring possible combinations of forms and colour variations. Because the modules or units have been significantly manipulated, and recombined in a different ordering from what was presented in the article, for the final piece, a line carrying the full set of "units" (faithful to their original forms) was included, to reinforce the link between the underlying science in the original article and the artistic interpretation (figure V2.40).

Between physics and art: supporting material

Scientific background

Additional information on the underlying science was provided by Christopher Wileman, publisher of *Nonlinearity*:

"This paper is focused on the comparison of quantum and classical mechanics via the analogy of the relationship between ray-based optics and wave-based optics in an optical system. Classical mechanics is very deterministic, i.e. if we know the rules of a system we can predict what will happen; quantum mechanics, although governed by laws, is based on probabilistic predictions calculated using those laws. Ray-based optics treat light as 'rays', or lines, whereas wave-based optics treats the light as, unsurprisingly, waves – this is analogous to the relationship between classical and quantum mechanics.

In this paper the authors model an optical system – lenses, prisms etc – via mathematical procedures operating on a baker map in phase space (phase space being an imaginary space in which the 'state' of a system can be represented). Figure 1 shows the basic baker transform; there is a unit square (i.e. a 1 by 1 square) with the *p* axis being the vertical axis and *q* the horizontal axis. This unit square is then stretched in the *q* dimension and squashed in the *p* dimension and the right-hand half (coloured light grey) is 'cut off' and put on top. This is one of the simplest examples of a completely chaotic system. Figure 3 is a similar but more complex transformation of the baker's map. These procedures now represent an optical system of lenses and prisms and the changes to the system as light passes through it."

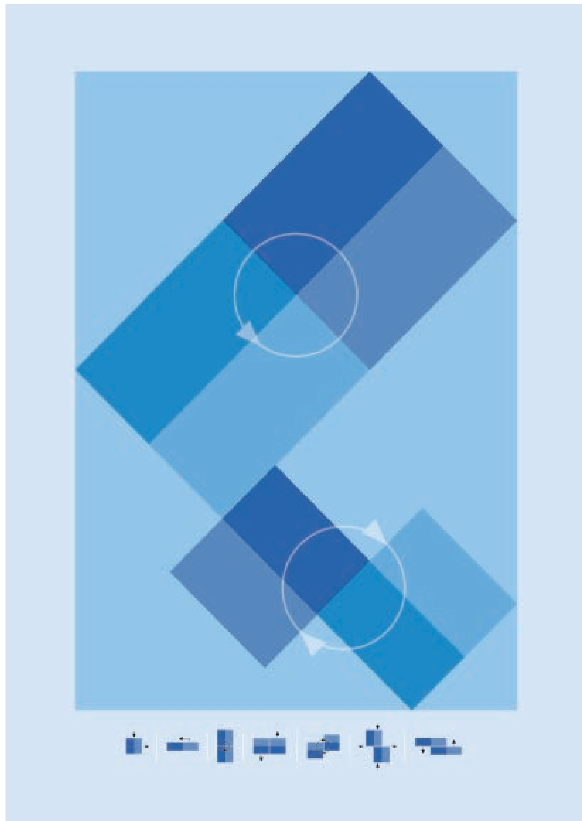


Figure V2.41: Final artwork, *Phase Space* (2012), 300 × 400 mm, archival pigment print, limited edition of 10.

Comment from the author

The two main points of our paper were that, first, a transformation that generates very 'chaotic' (complex and irregular) dynamics can be broken up into a sequence of very straightforward transformations - squashing, stretching, rotating, cutting and rearranging - and that, second, these transformations can be realized by a series of simple optical components (prisms and lenses). By studying how light as a wave passes through these components, we were able to analyse, by analogy, the quantum mechanics of the original transformation. Fred's work is interesting in this context because it is itself a transformation of our original figure; so a transformation of our transformations.

Many of the articles in *Nonlinearity* relate to iterated transformations, and what Fred has done exemplifies that. Her art has become an example of the ideas that inspired it. It has captured the essence of the mathematics. Also, the way we visualize it relies on optics, so it is itself an optical transformation of the kind we imagined. In this sense the art and the science have become intertwined, or self-referential. What she has added is colour, and this brings the process to life.

Professor Jonathan Keating,
Department of Mathematics, University of Bristol

Visual Rhythmetics

Series of posters exploring the correspondence between geometrical composition and the devising of an underlying coding system.

This series is based on the idea of a direct equivalence between data and visual. In its initial stage, it is informed by graphics found in an article by Huppertz and Emme,[1] where the scientific diagrams are accompanied by a set of squares and numbers (figure V2.42). These notations describe information conveyed in the image, through adopting a coding system. The exact nature of their meaning is not of interest here, only the principle of using symbols to represent information inherent in the visual.

Redacted due to copyright

Figure V2.42: Fragment of figure 2 in the article. Of particular interest is the line of symbols and numbers underneath the diagram.

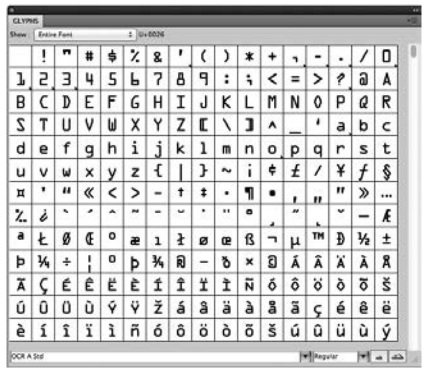
Also interested in mathematical notation, I quickly started to experiment with the typeface Mathematical Pi which provides a extensive family of signs, generally used for equations and mathematical descriptions. Figure V2.43 shows the charaters available in the Math Pi font family.

In terms of image construction, several stages took place: firstly, setting the space, here based on the standard A2 size (594 × 420 mm), I experimented with various proportional deconstructions using basic geometrical shapes, in particular the square and triangle. Secondly, colours are used for their functional and modular qualities – I allocated colours for each unit or module aiming to establish a visual rhythm defined by their location within the overall composition. Thirdly, I was looking for a way to capture hidden information intrinsic to the visual but only visible or available during the construction process, within the imaging software. I established a coding system using numbers and symbols to accompany the visual, in essence to become a part of the layout.

In terms of colour research, the focus is given by elaborating a balanced visual rhythm with carefully selected gamuts. Colours may seem to be chosen arbitrarily; however, the underlying approach is driven by exploring a near-perfectly balanced visual feel, which I tried to achieve through a precise selection of hues and tones, so each colour and position responds to its neighbouring equivalent.

The numberings and symbols are composed in a way that captures specific information in relation to the identification and colour value for each element in the artwork. Although very basic, the resulting "data" collection is intended to be reminiscent of scientific notation found in specialist research articles. Furthermore, the graphical qualities of the typeface chosen for the numbers have been carefully considered, using the font OCR-A for its distinctive look-and-feel: very few fonts have been designed such that each digit takes up the same space as a unit (i.e. the space taken by "1" is equal to "8"). OCR-A was designed specially for an early generation of automatic computing systems and data-driven printing processes, which was deemed particularly suited to working alongside the visual in this particular research.

[1] From the article: Huppertz, H. and Emme, H. 'Preparative and structural extension of oxoborate chemistry through high-pressure/high-temperature syntheses' in *Journal of Physics: Condensed Matter* vol. 16, no. 14 (2004), pp. S1283-S1290.



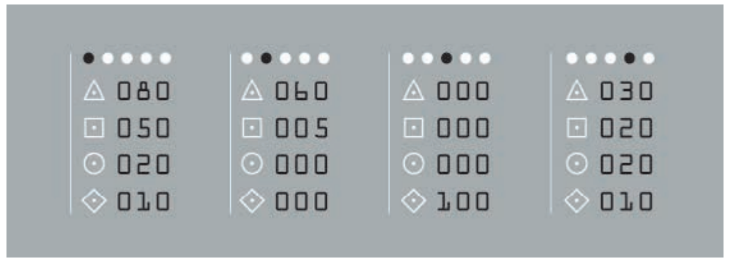


Figure V2.43 (far left): Shows the Mathematical Pi typeface family, with some of the lettering and symbols available from the font family.

Figure V2.44 (left): Shows the OCR-A typeface, with a selection from its extended family of letterings, marks and symbols.

Figure V2.45 (below, left): An example of coding system devised for this series of artworks, capturing information hidden in the visual composition. The symbols and numbers have been arranged in a grid system, reminiscent of automated processes. Because the colour scheme uses muted gamuts, the deployment of both white and black is particularly suited to establishing a visual hierarchy, hence also serving as colours in this context.

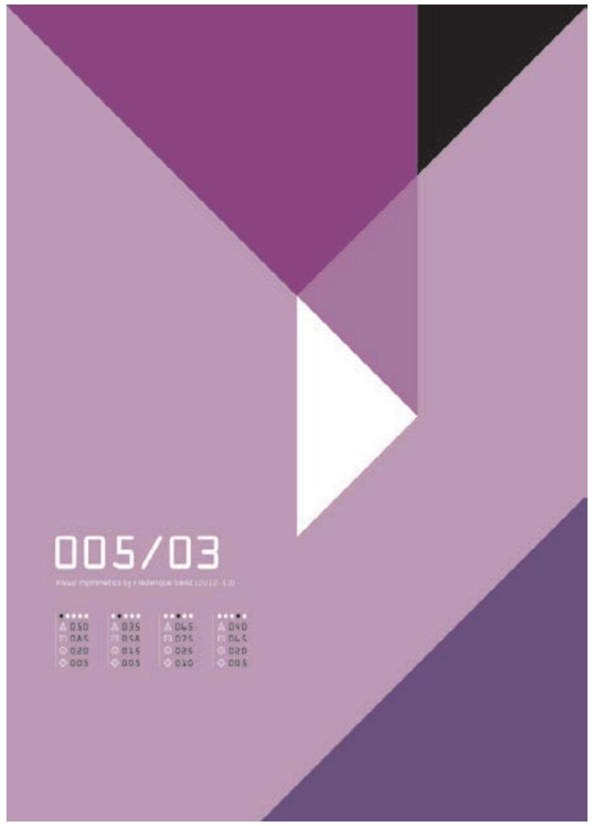


Figure V2.46: *Visual Rhythmetics* 005/03 (2013), litho print, 594 × 420 mm.

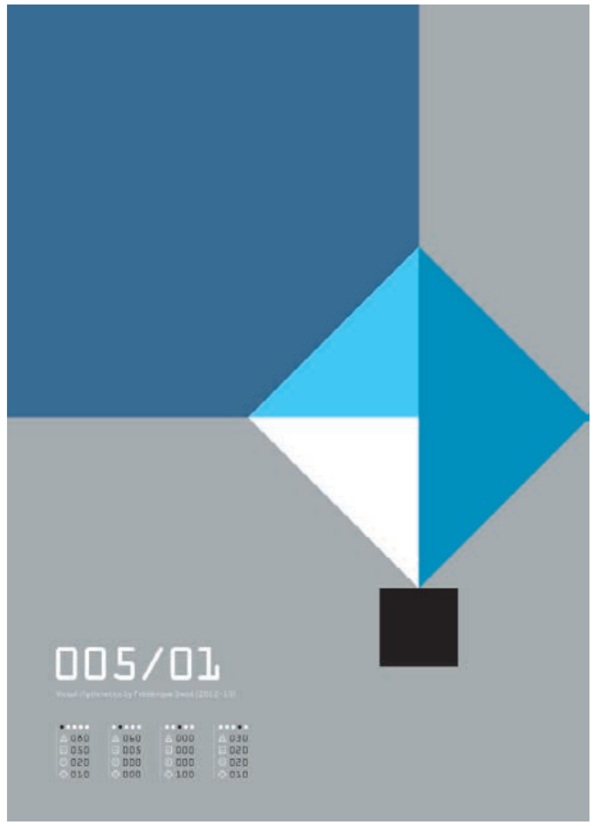


Figure V2.47: *Visual Rhythmetics* 005/01 (2013), litho print, 594 × 420 mm.

Figures V2.46 and V2.47 show two artworks from the series, illustrating the "data-visual" concept I have developed in this research. In addition to the underlying strategy as explained in this section, the visual strongly resonates with modernist designs (a source of inspiration often present in my work), conveyed in this instance through rationalising space and favouring crisp geometric arrangements.

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Typopgraphy
- Body text: Minion from Linotype, designed by Robert Slimbach (1990)
- Secondary font: Helvetica Neue family, originally designed by Max Miedinger (1957)

Printing

Brochure produced on X-Per Premium White, from the Fedrigoni collection. X-Per is PH neutral, chlorine-free and FSC certified, with a special treatment finish on both sides to enhance the surface and to allow a particularly bright and sharp printing. Self-cover: 140gsm.

Printed on the HP Indigo 5500, a high-definition digital press, with a print resolution of up to 230 lpi. Printed at Ripe Digital Ltd, Corsham, Wiltshire, UK (www.ripedigital.co.uk). Special thanks to George Penny and the production team at Ripe for their technical expertise and advice.