The White Rabbit and his watch spark the temporal theme in *Alice's Adventures in Wonderland*.

MATHEMATICS

Alice in time

Gillian Beer chronicles the passage of time in its many manifestations through Lewis Carroll's enduring classics.

Time haunts both Alice books. Lewis Carroll, author of *Alice's Adventures in Wonderland* (1865) and *Through the Looking-Glass* (1871), was also Charles Dodgson, mathematician and logician, and so was aware of the disturbing arguments, new in the mid-nineteenth century, that suggested our view of the geometry of space and time was not universal.

As Dodgson, he was a devout Euclidean, believing that planes are flat and parallel lines never meet. As Lewis Carroll, he stepped across those boundaries.

Carroll saw problems of temporality as fundamental both to logic and to

NATURE.COM

For more on Charles Dodgson the mathematician: go.nature.com/fq9eem

possible worlds. In *Alice's Adventures in Wonderland*, time sparks the whole adventure. When Alice sights the White Rabbit at the start, the animal mutters about lateness, but it is the timepiece that startles her: "When the Rabbit actually *took a watch out of its waistcoat-pocket* [Carroll's italics], and looked at it... Alice started to her feet".

Belatedness, anxiety and physical props such as the watch bespeak the individual under the cosh of time-regulated society. Watches had become established as a token of human respectability and, along with the factory clock, were the instruments that

controlled industrialized labour. Carroll was a railway enthusiast, and the Alice books appeared when railway timetables required the regularizing of time across Britain.

During Carroll's lifetime, space and time came to be understood more and more as linked concepts. Chronometers kept time at sea and helped in the mapping of colonial claims, bringing time and space together. The new technology of the photograph, of which Carroll was an early adept, froze and made portable a moment and a place. And, as Jimena Canales pointed out in her book *A Tenth of a Second* (University of Chicago Press; 2010), that particular time unit had new significance, especially in measuring the speed of thought and reaction time.

German physicist and physiologist Hermann von Helmholtz was in the vanguard of such discoveries — including the measurement of the speed of the nerve impulse — from the 1850s. In an 1870 *Academy* article, 'Axioms of Geometry', he summarized many non-Euclidean insights of the previous two decades, such as the possibility of parallel lines intersecting. He ended by citing German mathematician Georg Riemann's "somewhat startling conclusion, that the axioms of Euclid may be, perhaps, only approximately true". In this spirit, Helmholtz asserts the logical congruity of conceiving intelligent beings living on squashed planets, or in two or four dimensions.

Carroll did not follow this non-Euclidean thinking professionally, but let it loose in his fiction. So Alice shrinks and swells, is crushed into the space of the Rabbit's house or finds her head swaying on an elongated neck in the canopy of a tree. In this alternative space and time, her body's shape is not constant and its relation to its environment is approximate. The child's everyday and helpless experience of growing, and of being always the wrong size in a world designed by adults, is meshed with new mathematical speculations.

But echoes and reflections of industrial, scientific and technological changes are not the only markers of temporality in these books: sundials, solar time and dreams each add their diverse processes.

The wayward non-causal sequences experienced in dreams nudge the episodes onward in both books. Dreams share with narrative the property of presenting experience as simultaneously in the past and yet in process. The games in the books — cards, croquet and chess — do not unroll within a rigid time frame. But they involve strategic moves, giving them a time-driven urgency. So in the looking-glass world, Alice does eventually become a queen when, as a pawn, she reaches the end of the chess board. But that purposeful drive is subverted by the backwards order of things behind the looking-glass, where the White Queen screams before she pricks herself, and to stay in one place you must run fast.

Alice in Wonderland

Tate Liverpool, UK.
4 November 2011
until 29 January 2012.
www.tate.org.uk/liverpool

Carroll seems to have conceived *Through the Looking-Glass* on the plane of a chess board, later adding the optical reversing effects of the mirror. That pairing echoes the thought experiment described by his friend, J. J. Sylvester, in his presidential address to the 1866 British Association for the Advancement of Science mathematical and physical section. Using the analogy of a flat bookworm on a flat page entering three dimensions when the page is curved, Sylvester said that our three-dimensional existence can reach into the fourth dimension in the same way,

“The Hatter has quarrelled with Time and now they are stuck: ‘It’s always six o’clock ...’”

“analogous to the rumpling of the page”. Alice, like the bookworm, can both move across the two-dimensional chessboard and bulge into a different dimension through the mirror.

This suggests a new equivocal understanding of how time and space may be rumpled. In *Through the Looking-Glass*, Alice becomes aware that our mode of living in time is not the only pattern available. The Red Queen, hearing that days come one at a time in Alice’s country, says, “That’s a poor thin way of doing things. Now here, we mostly have days and nights two or three at a time, and sometimes in winter we take as many as five nights together — for warmth, you know.”

This merging and crossing between different modalities of time explains the attraction of Alice for the surrealists: Salvador Dalí’s brilliant illustrations pithily express the dream-time of Alice. They show the child leaping and dancing, with her shifting shadow always at just the wrong angle to the Sun.

Some of the more remarkable effects in

Alice’s trip through the looking-glass could have been inspired by the theory of other dimensions.

Alice are customary to us now. The elision and flow from one scene into the next (queen into sheep, shop into river) correspond as much to the editing processes of cinema as to the motions of dreams. Our familiarity with slow-motion photography may also make Alice’s leisurely fall into the underworld less astonishing, even though the alternatives suggested by the narrator offer the deep absurdity of the choice that is not a choice: “Either the well was very deep, or she fell very slowly, for she had plenty of time as she went down to look about her.” A body falling down a well, however deep, is rarely leisurely.

Carroll allows objects to retain their lethal weight in motion even while Alice floats down: gravity here is erratic in action. Alice must be ten times as heavy as the empty marmalade jar she picks off a shelf, but in

this instance she dawdles through the air while worrying about the jar falling and killing someone below. This reverses the usual error, mocked by philosopher John Stuart Mill — ‘the belief that a body ten times as heavy as another falls ten times as fast’.

Laws of motion had, for the Victorians, become one of the most controversial aspects of time. The Mad Hatter’s tea party combines the two. The Hatter claims Time as an ally during the tea-table argument, when Alice becomes exasperated, saying that the Hatter might do “something better with the time ... than wasting it in asking riddles that have no answers”.

“If you knew Time as well as I do,” said the Hatter, “you wouldn’t talk about wasting it. It’s *him*.” But it turns out that the Hatter has quarrelled with Time and now they are stuck: “It’s always six o’clock now ... it’s always tea-time, and we’ve no time to wash the things between whiles.”

Instead of time moving, they must move round the table forever as if on a clock face — and Alice soon ends up with the March Hare’s dirty tea-things in front of her. Tea-time is, of course, not an instant but a period, so the participants can continue their own lives and conversations within the arrested time. That the Hatter’s watch “tells the day of the month, and doesn’t tell what o’clock it is” is in keeping with this temporal stasis.

Only a few years after the Alice books, in 1874, German mathematician Georg Cantor argued in his theory of sets that there are degrees of infinity as well as an infinite infinity that, for mathematicians, eased the paradox of the continuity or discontinuity of motion. The teasing question of infinities had already been recognized by Alice who, talking to the Hatter about the process round the tea table, asks, “But what happens when you come to the beginning again?”

Luckily, Alice can walk away. She is not imprisoned in their eternal loop (and, it turns out, neither are they: the Hatter becomes a witness in the trial scene, and reappears in *Through the Looking-Glass* as the Anglo-Saxon messenger Hatta).

This is not a systematic fiction. It is a field of play. Time here, as in a mathematical manifold, makes Euclidean sense only locally; the whole resists resolution. The various forms of time will not lie still together; they are rumpled and energetic, endlessly alluring Alice. ■

Gillian Beer is professor emeritus of English literature at the University of Cambridge, UK, a fellow of the British Academy and author of *Darwin’s Plots* (2009, third edition).

This is an edited and abridged version of *Time’s Manifolds* by Gillian Beer, taken from the catalogue accompanying the exhibition *Alice in Wonderland* at Tate Liverpool (Tate Publishing, 2011). Reproduced by permission of Tate Trustees, © Tate 2011.

The Mad Hatter’s non-stop tea party draws on ideas about infinity and the laws of motion.