Review

What It Takes to Film Mathematics

The Mathematical Films of Ekaterina Eremenko

Reviewed by Oliver Gross

How does one convey what one's own profession is really about? Many lines of work leave visible traces that make their purpose legible even to those outside the field. In medicine, the act of treating patients is concrete, while in engineering the presence of bridges, instruments, and machines places the work directly in the physical world. Mathematics, by contrast, does not reveal itself so readily. Though substantial, its impact on the world often appears only indirectly, embedded in layers of technology, science, and design. What remains visible is usually the application rather than the mathematics itself. This occlusion leads to familiar misconceptions: the solitary mathematician, the fixation on puzzles, or the sense that mathematics stands apart from ordinary experience. These challenges force mathematical filmmaking to rely on devices that stand in for the invisible work, and this is precisely where Ekaterina Eremenko's approach to filmmaking begins (see [1] for her complete filmography).

Here, we shall examine her films from this perspective, considering how they respond to the challenge of showing mathematics on screen. A film about mathematics cannot point a camera at the central object of study. It cannot record the decisive moment of a proof, nor can it rely on the natural vocabulary of action that other professions offer. The very activity that defines the field is abstract, internal, and slow—at least when compared to other fields of science that frequent contemporary news headlines.

Filmmakers must respond to this obstacle by developing substitutes for what cannot be shown directly. Eremenko uses place, testimony, and fragments of mathematical explanation to make visible the parts of the discipline that resist the camera, showing the settings in which mathematicians think, the historical circumstances in which ideas arose, the conversations in which half-formed thoughts take shape, and the long stretches of uncertainty that precede genuine insight. One of her strategies is to use historical context as a bridge. By filming in the places where mathematicians lived and worked and by tracing how their ideas were received, she gives physical form to processes that would otherwise remain hidden. Another of her techniques is to show mathematics in practice: the discussions, the disagreements, the tentative steps, and the slow accumulation of understanding that characterize contemporary research.

Within this demanding framework, Eremenko's films hold a distinctive place. They do not reduce mathematics to its applications, nor do they rely on the stereotypes that arise when the discipline remains unseen. Instead, they reveal mathematics as a lived activity shaped by place, by history, and by the communities that pursue it. In doing so, her work opens a view onto a discipline whose intellectual life is essential yet rarely visible from the outside.

A Long Winding Path from Mathematics to Filmmaking

Ekaterina Eremenko's path to filmmaking emerges from a sequence of transitions that link mathematical training, personal loss, and the search for a new creative language (personal communication; see also [10]). Born in Moscow

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to a family of scientists, she grew up in an environment in which scientific curiosity was the norm. Her early education in a specialized mathematics and physics school, where she graduated with the highest distinction, placed her among students who would later become prominent scientists. She carried that momentum into her graduate studies at Moscow State University, and although an academic direction seemed assured, personal tragedy disrupted that trajectory, leading her to step away from mathematics while she tried to rebuild her life.

For a time she worked as a model, a detour that introduced her to a different kind of discipline and gave her a sense of creative agency far removed from academic mathematics. Later, she moved into television anchoring, which provided her first sustained experience with production, demanding a pragmatic approach to producing footage that could later be shaped into a coherent narrative. Both roles became early training grounds for the creative skills she would draw on as she moved behind the camera. Admission to a directing program gave that new focus a more formal framework, aligning her developing interests with a disciplined training in film. Not long afterward, she began collaborating with established producers and broadcasters, a set of partnerships that played a central role in shaping her growth into the award-winning filmmaker she is today. After more than a decade at TU Berlin, she is now based at the Max Planck Institute for Mathematics in the Sciences, where she is working on her latest film, about Felix Klein.

These experiences shaped her filmmaking style: the clarity of mathematical thinking, the improvisation required in early television work, and the sensitivity to people and place all reappear throughout her films.

Portraits

A central part of Eremenko's work is films that portray influential mathematicians by interweaving biography, intellectual context, and contemporary assessment. Rather than offering a tightly structured exposition, these films take the form of a mosaic assembled from interviews, locations, and fragments of mathematical explanation. The effect is neither conventionally narrative nor purely didactic. It resembles the process of reconstructing a historical figure from the traces the person left behind, shaped by the diverse voices that comment on them today.

A distinctive feature of these films is Eremenko's sustained use of locations. She does not merely refer to the settings in which Cantor, Ladyzhenskaya, or Lobachevsky lived and worked, but she films at those sites, allowing the surroundings themselves to establish historical and emotional continuity. In *Georg Cantor* [2], the movement from St. Petersburg to Berlin and Halle traces the arc of Cantor's life while visually marking shifts in the reception of his ideas. In the *Olga Ladyzhenskaya* portrait [6], brief glimpses of university corridors and archival rooms accompany interviews and anecdotes, creating a sense of the institutional environment in which she worked while letting the personal stories carry the film. In *Lobachevsky Space* [4], the transitions between Einstein's house, lectures in Berlin, Kazan's university buildings, and the Volga region serve as a geographic counterpart to the development and dissemination of hyperbolic geometry. These places carry the weight of memory, and their inclusion allows the films to gesture toward historical depth without explicit explanation.

The absence of a narrator is central to this approach. Instead of a guiding voice that binds the material together, Eremenko relies on mathematicians, students, colleagues, historians, and family members to construct the portrait. Their remarks are not always aligned. In the film on Cantor, the rapid alternation between experts in Berlin and Halle mirrors the tension between Cantor and Kronecker, leaving the viewer to piece together the sources of their conflict. In the film about Ladyzhenskaya, anecdotes of warmth and admiration appear alongside accounts of difficulty and criticism, suggesting a more nuanced character than a celebratory documentary would typically allow. In the Lobachevsky film, differences between Russian and Western perspectives surface naturally, sometimes revealing more about the contemporary commentators than about Lobachevsky himself. The result appears intentionally discontinuous. Moments of clarity are interspersed with passages that demand prior knowledge, and the viewer is expected to infer connections that a narrator would normally supply (Figure 1).

Figure 1. A collection of film posters of Eremenko's portrait-type films [2, 4, 6].

Another recurring device is the careful integration of mathematical explanations. These films try not to require that the viewer be familiar with the subject matter, without at the same time presenting an oversimplification. With frequent collaboration from Alexander Bobenko, a professor of mathematics at TU Berlin, Eremenko introduces key ideas through illustrations, animations, and brief sequences in lecture halls. In the Cantor film, playful animations explain one-to-one correspondences, the diagonal argument, the structure of the Cantor set, and Hilbert's hotel, all presented with a lightness that contrasts with the gravity of Cantor's personal struggles. In the Lobachevsky film, Bobenko's explanations range from satellite navigation and the practical relevance of general relativity to visual introductions of hyperbolic geometry. These passages establish a thread of accessibility, but they also mark a limit: some comments, especially those made in passing by senior mathematicians, presuppose familiarity with the underlying mathematics. The films accommodate this by allowing experts to speak in their natural register, even when it risks excluding part of the audience.

This mixture of clarity and opacity can be understood as deliberate. It mirrors the way mathematical understanding develops, in moments of insight surrounded by incomplete information. Eremenko chooses to convey personality, setting, and mathematical thought through the material that naturally arises when people talk about figures they admire, contest, or struggle to understand. The film *Olga Ladyzhenskaya* exemplifies this. Her achievements in partial differential equations, especially on the Navier–Stokes equations, are described not only as technical milestones but as shared problems that connected mathematicians across geopolitical divides. The anecdotes that surround her, stories of resilience, sharp intellect, and occasional friction, collectively portray a mathematician embedded in her time. Similarly, in *Lobachevsky Space*, admiration and mythology coexist with uncomfortable facts, such as accounts of the harsh treatment of peasants and the disparity between reverence for Lobachevsky and the harsh judgment of his wife by local storytellers. These divergences are not resolved, but remain part of the composite.

Taken together, these films define a distinctive genre within Eremenko's body of work: biographical portraits that rely on place, testimony, and mathematical insight to capture the complexity of figures whose work has shaped modern mathematics. The approach is demanding. It requires the viewer to navigate shifting voices and incomplete narratives. Yet it also creates a richness that a more linear format would lose. By letting the portraits remain layered rather than polished and by not smoothing their edges, Eremenko invites the viewer to experience the subjects not as abstract heroes but as individuals situated in a world that was, like the mathematics they created, intricate and unsettled.

Contemporary Research from Within

In contrast to her biographical films, a second genre in Eremenko's oeuvre focuses not on particular historical figures but on the activity of mathematics itself. These films invite the viewer into research environments, showing what it means to work collaboratively, to develop ideas gradually, and to navigate the mixture of intuition, structure, and uncertainty that shapes contemporary mathematics. They are not instructional films in the usual sense, but they offer instead a portrait of mathematical practice from within.

The Discrete Charm of Geometry exemplifies this approach. Filmed inside a collaborative research center led by Alexander Bobenko at TU Berlin, it presents geometry as both an active field of inquiry and a lived culture [9]. The center's field of speciality, discrete differential geometry, seeks to construct discrete theories that mimic essential features of continuous differential geometry and recover the classical setting in the limit of refinement. What begins as an attempt to produce a visually appealing computational experiment soon opens into deeper questions: how to define conformal mappings on surfaces with different topological properties, and how to choose among competing discretizations. The film follows these questions as they emerge in seminars, hallway conversations, and informal exchanges in front of blackboards. The viewer witnesses mathematicians arguing, hesitating, revising, and discovering, often in short fragments that convey the texture of daily work more vividly than any formal explanation could.

Again the use of location remains essential. The film's locations move between places such as Berlin and Paris, linking theoretical developments to architectural applications in the Louvre and the Eiffel Tower. These excursions underscore that not only is discrete differential geometry a theoretical interest, but it also has a visible presence in the built environment. Prominent scientists, including Freeman Dyson and Dennis Sullivan, appear in brief sequences that signal the intellectual significance of the work. Eremenko also portrays the researchers as individuals with interests beyond mathematics, highlighting the need for balance and perspective. Rather than isolating research from life, she allows the two to interpenetrate.

Embedded within the film is an early glimpse of a problem that will later receive sustained attention: the Bonnet problem. Bobenko describes it in passing, and the mention is easy to miss. Only in retrospect does this moment reveal itself as a seed for *Solving the Bonnet Problem* [8], a film that tracks a group of mathematicians as they confront an open question dating back to the nineteenth century. What distinguishes this film is that Eremenko began filming long before the outcome was known. She documented the process with surprising completeness, beginning with Bobenko's tentative idea and concluding with the construction of a counterexample to a long-standing conjecture. This achievement by Alexander Bobenko, Tim Hoffmann, and Andrew O'Shea Sageman-Furnas is shown not as a triumphant conclusion but as the culmination of intertwined lines of thought that involved continuous and discrete differential geometry, filling of gaps in Darboux's historical work, and a willingness to follow ideas wherever they led. In retrospect, the brief mention of the Bonnet problem already points toward the narrative of a later film, though at the time there was no indication that progress would eventually be made (Figure 2).

The structure of the film *Solving the Bonnet Problem* combines present-day research with historical context. Fields laureate Cedric Villani serves as an occasional live narrator, speaking in front of Bonnet's grave in Paris, while Jean-Pierre Bourguignon anchors the historical thread in the academic

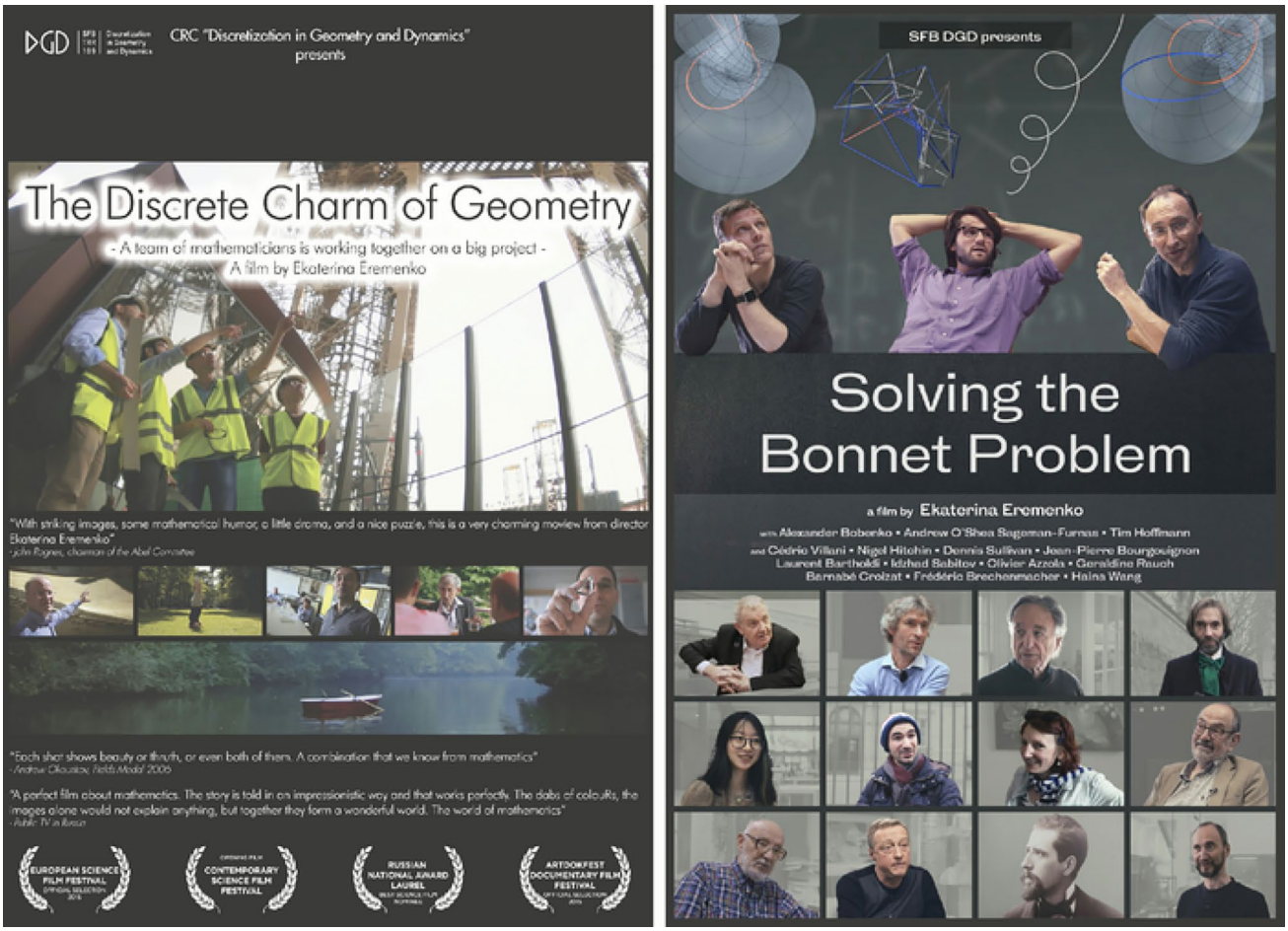

Figure 2. Film posters showing two of Eremenko's films [8, 9] that allow for a glimpse of what mathematics may look like from the inside.

world of the École Polytechnique, giving Bonnet's nineteenth-century context a clear and concrete setting. Idzhad Sabitov contributes a short reflection on discovering a gap in his earlier argument, underscoring the film's attention to the human side of mathematical work. Set against this background, Bobenko's explanations and the accompanying visualizations guide the viewer through the geometric core of the story.

Both films draw attention to the specific tools and habits that support mathematical work. Visualizations play a central role, especially in geometry, where computational experiments can illuminate possibilities that pure existence proofs cannot. The films show how mathematicians negotiate competing definitions, and how the apparent absence of a single correct approach motivates the search for broader unifying theories. At the same time, Eremenko captures the human dimensions of research: the intensity of discussions, the relief of progress, the need for community, and the sober recognition that mathematics, however absorbing, is only one part of life.

Taken together, these films offer a rare depiction of mathematical practice as it unfolds in real time. They do not polish or simplify. Instead, they show mathematics as a collective enterprise shaped by curiosity, disagreement, patience, and the interplay of ideas across generations. If the biographical films seek to understand the past through place and testimony, these research films show how the future is built: through conversations, conjectures, revisions, and the persistent effort to see clearly.

Popularizing Mathematics

In a third strand of her work, Eremenko turns to the question of how mathematics reaches beyond its own community. These films are not concerned with historical figures or with research from within, but with the ways mathematics enters public life and how people with very different backgrounds encounter it. They explore what happens when mathematics steps into unfamiliar environments, where its values, methods, and expectations meet other cultures of thought. The results are often lively, sometimes dissonant, and always revealing of what it means to communicate mathematics outside its usual boundaries.

Her film *Head, Heart and Soul* examines a competition in which participants create art inspired by mathematical ideas [3]. The event begins with lectures on mathematical topics delivered under an unusual constraint: no formulas are allowed. This already signals a tension between mathematical habits of expression and the expectations of a broader audience. Participants come from a variety of fields. Mathematicians, architects, designers, and students explain their motivations in ways that reflect the diversity

Figure 3. Film posters showing two of Eremenko's films [3, 5] that report about efforts to popularize mathematics.

of their backgrounds. Some hope to win, while others are drawn by the interplay between structure and visual form, or simply enjoy the chance to participate without caring about the outcome. The competition becomes a point of contact between worlds that ordinarily do not intersect.

After the entries are presented, the film shifts its focus to the conversations that follow. Participants debate what counts as art, what counts as mathematics, and whether the two can be combined in a meaningful way. The contrasting expectations are striking. The exchanges in the film reveal different expectations among the participants. The mathematicians in the group look for clarity, precision, and well-defined criteria, seemingly uneasy when an artwork refers to mathematical ideas without following their internal logic. The artists respond from their own perspective, questioning whether mathematical exactness has any intrinsic aesthetic significance. The film captures the moment when these perspectives meet, neither fully reconciling with the other nor fully rejecting it, but revealing the gap between them. Eremenko does not attempt to resolve the tension and allows the viewer to see how each group negotiates ambiguity, defends its assumptions, and responds to being challenged. The result is an exploration of outreach that is neither celebratory nor critical, but attentive to the complexity of genuine exchange. The film highlights how difficult it can be to communicate mathematical structure without the symbolic and visual language mathematicians rely on.

The film *Math Circles Around the World* approaches popularization from a different angle, focusing on voluntary programs in which children work on mathematical problems guided by mathematicians and older students [5]. These circles offer an alternative to the structure of school mathematics. They ask participants to think about problems that are more open, more playful, and more demanding than what they encounter in school. The film emphasizes that the time commitment is significant, and students choose to take it on despite having many other obligations. Apparently, the circles give them access to a kind of mathematics that is otherwise missing: problem solving in its natural form. The challenges are varied and imaginative. A sudoku puzzle becomes an exploration of how many clues are needed for a unique solution. A riddle about poisoned apples or ants moving on a stick encourages strategic thinking and creativity. Students are even invited to present favorite problems they have solved, or ones they cannot yet solve, explaining both their successes and their impasses (Figure 3).

These settings create a space that is far from the competitive atmosphere of typical schooling. Students work in teams, discuss ideas freely, and learn to articulate their reasoning. They acquire social skills as much as mathematical ones, practicing how to disagree, how to explain, and how to listen. The instructors are enthusiastic, often volunteers who were once circle participants themselves.

They bring a sense of continuity and community, and many younger leaders operate closer to the students' young age, making the environment approachable. The circles also provide a haven for children who are particularly gifted or unusually curious, giving them access to peers and mentors who understand their interests. The joy of these interactions is palpable, and the film makes clear that the circles succeed not because they simplify mathematics, but because they give students an entry point into genuine exploration.

Taken together, these two films reveal yet another aspect of Eremenko's approach to mathematics: her interest in how the discipline she was drawn to from an early age is transmitted, interpreted, and reshaped when it enters the wider world. In one case, mathematics moves into an artistic setting and must negotiate unfamiliar expectations. In the other, it becomes an invitation to young learners who approach it with openness and curiosity. In both cases, Eremenko shows that outreach is not simply a matter of explaining mathematics. It is a meeting of perspectives, each with its own assumptions and values. Her films highlight the richness of these encounters and the way they broaden the discipline's presence beyond the confines of research and academia.

Her newest film, *PolyMaths* [7], turns to the question of how mathematical education shapes careers beyond science and follows a graduate student at a crossroads alongside people who have taken very different paths.

Final Thoughts

Eremenko's films present mathematics from angles that are rarely available to a wider audience. Although her work might fall short of being accessible to a broad public, it invites curious viewers to glimpse a side of mathematics that is rarely displayed, showing the discipline through the places where it is practiced, the people who shape it, and the long arcs of thought that underlie its achievements. They also show the tensions, the uncertainties, and the moments of genuine excitement that mark the work of researchers, students, and teachers. The portraits, the glimpses into contemporary research, and the efforts at outreach form a body of work that is unusually rich in perspective. They collectively illustrate mathematics not as a collection of isolated insights, but as a culture shaped by memory, collaboration, and the slow accumulation of understanding. Each film reveals a different facet of that culture, and together they make visible a discipline that is often misunderstood.

This review is inevitably shaped by a familiarity with parts of the mathematical world they portray. Having spent my doctoral studies within the same research center where some of the filming took place, I recognize many of the people and situations that appear on-screen. That proximity influences what I notice, but it also gives me a sense of how much attention and patience were required to capture these environments, the atmosphere of discussion, the mixture of focus and informality, and the slow movement of ideas. This review is therefore a personal and subjective description of what Eremenko's films show, and it reflects nothing more than my own reading of her films: an attempt to portray mathematics as a collective and deeply human endeavor.

Acknowledgments

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