

GEOMETRY, GRAPHICS AND DESIGN IN THE DIGITAL AGE

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Marko Jovanović

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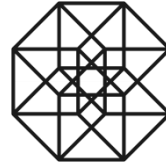
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Novi Sad, May 2023

Ivana Bajšanski and Marko Jovanović

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GEOMETRY, GRAPHICS AND DESIGN IN THE DIGITAL AGE

Proceedings

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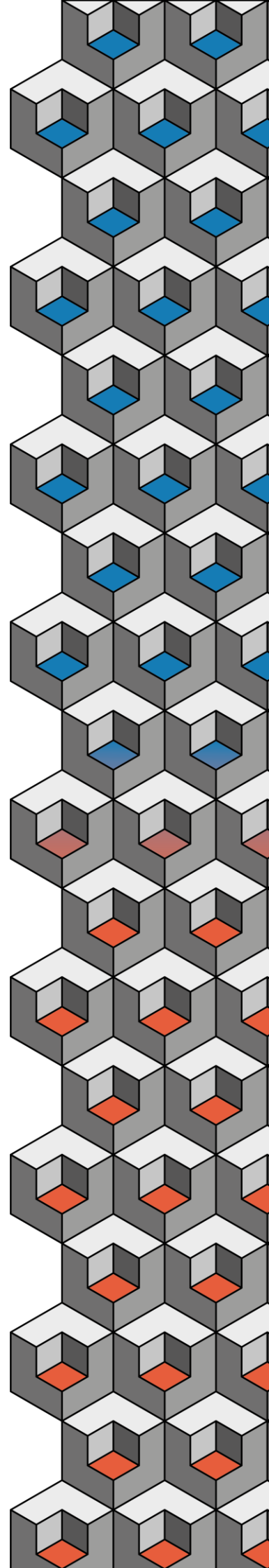


Table of Contents

Jovana Tomić, Sonja Krasić, Nastasija Kocić	
Optimization and rationalization in the design of floating settlements	1
Tanja Mitrović, Milica Vračarić, Vesna Stojaković	
Visibility analysis of urban spaces: Temporary structure layouts related to the quality of urban seating	7
Marko Vučić, Bojan Tepavčević	
Design and fabrication of depolluting façade system elements	15
Ina Pašić, Marko Jovanović	
Design and simulation of concrete panels cast in stencil constrained fabric formwork	25
Marko Lazić, Ana Perišić	
Algorithm for geometry optimization of complex building floorplan footprints into a grid of quads	33
Milica Pavlović, Marko Jovanović	
A case study of acoustic diffusers impact on echo reduction in auditoriums	43
Nastasija Kocić, Branislava Stoiljković, Sonja Krasić, Jovana Tomić	
Rationalization of ellipsoidal shell for prefabrication	55
Tashko Rizov, Aleksandar Jankovic, Risto Tashevski, Elena Angeleska	
Visualisation of autonomouos vehicle interior in virtual reality	61
Sanja Dubljević, Jelena Kićanović, Aleksandar Anđelković	
Integration of building information modeling (BIM) and virtual reality technology (VR) for daylight analysis visualization	69
Dragoş - Laurențiu Popa, Cosmin Berceanu, Gabriel Catalin Marinescu, Violeta Contoloru, Duță Alina, Daniela Doina Vintilă, Daniel Cosmin Calin, Gabriel Buciu	
Virtual simulations of some human anatomical systems	79
Miloš Obradović	
Various concepts of user movement within the immersive virtual space in architecture	93

Jelena Milošević, Ljiljana Đukanović, Milijana Živković, Maša Žujović, Marko Gavrilović

Automated compositions: Artificial intelligence aided conceptual design explorations in architecture 103

Jelena Pepić

Application of digital tools in the fabrication of tensile structures 117

Dirk Huylebrouck

A new family of solids: The infinite kepler-poinsot polyhedra 125

Gordana Đukanović, Đorđe Đorđević, Mirjana Devetaković, Đorđe Mitrović

Transformation of pencils of circles into pencils of conics and these into pencils of higher-order curves 133

Branislav Popkonstantinović, Miša Stojicević, Ratko Obradović, Ivana Cvetković

The gravity escapement – It all boils down to geometry 143

Đorđe Mitrović, Đorđe Đorđević, Mirjana Devetaković, Gordana Đukanović

Encoding/decoding capitals of classical architectural orders by using fractal geometry: Establishing methodology 153

Marija Obradović, Slobodan Mišić

Learning while playing - Througie platform for creating models of spatial structures 169

Aleksandra Stakić, Zorana Jeli, Nedeljko Dučić, Boris Kosić

An overview of the classification of four-bar mechanisms in view of the motion simulation in the matlab software package 181

Maja Petrović, Dragan Lazarević, Aleksandar Trifunović, Branko Malešević

Proposal of new constant slope surfaces for the purposes of designing traffic infrastructure elements 195

Marija Obradović, Anastasija Martinenko

A method for adjusting the shape of semi-oval arches using Hügelschäffer's construction .. 205

Hellmuth Stachel

The design of skew gears from the geometric point of view 217

Emil Molnár, Jenő Szirmai

On SL2R crystallography 229

Aleksandra Bobić, Marko Jovanović, Ivana Vasiljević

Environmental geometry generation in video games using photogrammetry and digital sculpting 247

Ivana Miškeljin, Igor Maraš, Marko Todorov

Experimental approaches to architectural visualization: Learning from visual arts 257

Milan Miščević, Ivana Vasiljević, Ratko Obradović

Types of level design structures in video game development..... 271

Vladan Nikolić, Olivera Nikolić, Jasmina Tamburić, Sanja Spasić Đorđević, Jovana Vukanić

Application of composite (hybrid) graphics in architectural representation 279

Isidora Mitrović

Reconstruction of the building using photogrammetry method – Case study of the chapel of st. George on mountain Rtanj 289

Isidora Đurić, Miloš Obradović, Vesna Stojaković

Free software for image-based modeling education: Comparative analysis – advantages and disadvantages 297

Mirjana Devetaković, Đorđe Đorđević, Nikola Popović, Đorđe Mitrović, Gordana Đukanović, Slobodan Mišić

On the other side of mirror – a workshop on incorporating geometry of mirroring in architectural practice and applied arts 309

Ludmila Sass, Alina Duta, Anca Barbu, Alina Elena Romanescu

Contributions to the study of da Vinci 's lunules 323

Sonja Krasić, Jovana Tomić, Nastasija Kocić, Zlata Tošić

Online teaching on a cademic course descriptive geometry at the Faculty of civil engineering and architecture in Niš 335

Naomi Ando

Application of bim to architectural design education..... 345

Domen Kušar, Mateja Volgemut

The correlation between students' spatial perception and academic success in the descriptive geometry course 357

Miša Stojićević, Branislav Popkonstantinović, Zorana Jeli, Ivana Cvetković, Boris Kosić	
Analysis of a ptc systems with moving focal point	371
Dragan Lazarević, Momčilo Dobrodolac, Maja Petrović, Aleksandar Trifunović	
Application of geometric modeling to improve the efficiency of the delivery phase in the e-commerce	381
Biljana Jović, Aleksandar Čučaković, Marija Marković , Katarina Bašić	
Sustainable solar lamp biodesign inspired by the crocus vernus l. Flower	389
Cosmin Berceanu, Alina Duță, Dragoș Popa, Anca Didu	
Considerations regarding the shape definition of an anthropomorphic robotic hand-arm system	399
Boris Kosić, Zorana Jeli, Aleksandra Stakić, Marko Rusov, Dragoljub Bekrić, Zaga Trišović	
Analisis of a four-bar linkage complaint mechanism for receiving approximately straight-line motion	407
Milan Stojanović, Pavle Ljubojević, Tatjana Lazović	
Simulation of involute gear tooth profile shaping	417
Gabriel Cătălin Marinescu, Ludmila Sass, Anca Didu, Oana Victoria Oțăt	
Modeling and analysis of some braking system parts	429

TRANSFORMATION OF PENCILS OF CIRCLES INTO PENCILS OF CONICS AND THESE INTO PENCILS OF HIGHER-ORDER CURVES

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Abstract

In this paper, an elliptical pencil of circles is mapped by homology (perspective collineation) into a parabolic-parabolic pencil of hyperbolas because it has two by two common points $1 = 2$ and $3 = 4$ in infinity, i.e., four overlapping points in the antipode. The mapping also includes the mapping of degenerated conics decomposed into corresponding pairs of straight lines. The elliptical pencil of circles (the ellipses on plane 1) is mapped into a hyperbolic pencil (on plane 2) by perspective collineation for pole S_1 . The vanishing line v_1 intersects all the circles of the pencil so that by homology all the circles are mapped into hyperbolas. To apply supersymmetry to the obtained pencils, the angle between plane 1 and plane 2 must be 45° . The pencil of hyperbolas is mapped by supersymmetry into a pencil of higher-order curves. The obtained pencils are further mapped by inversion and then again by supersymmetry to obtain higher-order curves rich in different shapes.

In the second example, the elliptical pencil of circles is placed to the vanishing line v_1 so that by homology, it is mapped into a pencil of conics containing an ellipse (circle 1 does not intersect the vanishing line), a parabola (circle 2 touches the vanishing line), a hyperbola (circle 3 intersects the vanishing line). The pencil of conics is elliptical-parabolic because it has two real and separate points and two infinite, i.e., two overlapping points in the antipode. This pencil of conic is also mapped by supersymmetry into a pencil of higher-order curves that intersect at the same number and type of base points as the starting pencil. Higher order curves obtained by mapping are rational line curves.

Keywords: pencils of circles, pencils of conics, inversion, supersymmetry, pencils of curves of the higher orders

1 INTRODUCTION

Professor Lazar Dvornikovic has made a significant contribution to the study of curves. Modern geometry has introduced the term observer (hence the term relativistic geometry) [3]. The term "plane" is replaced by "sphere" and the term "straight line" by "circle passing through the observer's antipodal point". Perception and interpretation of geometric elements depend solely on the observer's position. Through the observer's standing point on the "plane", a pencil of "straight" geodesics cuts through. Each of these largest circles on the sphere defines a pencil of straight lines that are parallel to them but are not geodesics. By moving away from the geodesics on both sides, the diameter of the circles decreases. (Fig. 1). For each direction at the antipode, there is one infinitesimal circle. Thus, we come to an unusual conclusion: Unlike the projective plane which has only one infinitely distant straight line for all observers, the relativistic "plane" has infinitely many infinitesimal antipodal "straight lines" for each (of ∞^2) observer individually. However strange it may be, this fact paves the way for creating a simple mechanism for the tying and untying singular points of curves.

A simple example in Fig. 1 shows the essence of relativistic geometry. It explains the concept of parallel lines. Regarding two parallel lines, projective geometry introduces the concept of an infinitely distant point where these two parallel lines intersect. Since parallel lines are equidistant, they can never meet, not even at infinity. Relativistic geometry explains the concept of parallel lines by the fact that an observer standing on a large sphere, on the geodesic marked with d (Fig. 1, d coloured black), perceives all the circles that pass through his antipodal point as parallel or intersecting lines. In the given example, the "straight lines" are parallel to the " d " geodesic of the sphere. By stereographic projection of circles from the antipodal point S_A (red and green circles shown in Fig. 1) onto plane T , a pencil of parallel lines (blue lines) is obtained. Therefore, the observer perceives the red and green circles on his large sphere as blue parallel lines.

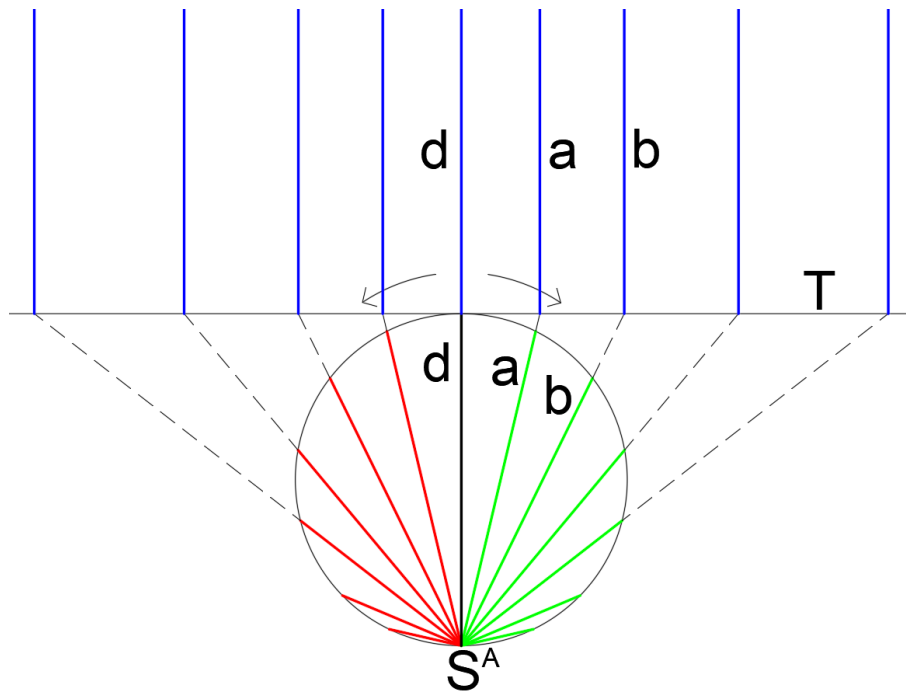


Fig. 1. Parallel lines in relativistic geometry

In relativistic geometry, curves are classified into harmonic groups. Fig. 2 shows the regrouping of curves according to the classical and relativistic order. Figure 1 was taken from "Quantum-relativistic geometry as a new scientific paradigm" [8].

The relativistic order of the curve equals the sum of its classical order and the number of times the curve passes through the antipode.

The "straight line" and circle are second-order curves because a "straight line" is a circle passing through the observer's antipodal point. Classical second-order curves have a double point at the antipode, which makes them fourth-order curves in relativistic geometry. The curves of the fourth order of the elliptical type (Fig. 2) have a double isolated point at the antipode. Hyperbolic curves have a double self-intersecting point at the antipode, and parabolic curves have a cusp where the two branches of the curve touch. When the laws of symmetry are applied to curves in a certain group, the properties of higher-order curves will depend on the leading curve in that group. The classification of curves into harmonic groups is of great value in the theory of geometry [4].

2 TRANSFORMATION OF AN ELLIPTICAL PENCIL OF CIRCLES

The following segment shows the mapping of elliptic pencils of circles into corresponding pencils of conics by homology (perspective collineation) which are then mapped by symmetry (for the centre S and the circular axis s) into pencils of higher-order curves. An inversion is then applied to the obtained curves (for the centre S_i and the circular axis s_i) [2].

2.1 Parabolic-Parabolic (PP) pencil of conics

The elliptical pencil of circles (i.e. ellipses on plane 1 seen as circles in the first projection) which is projected into (2) elliptical pencil of hyperbolas with two pencils of parallel asymptotes is shown in Fig.3.

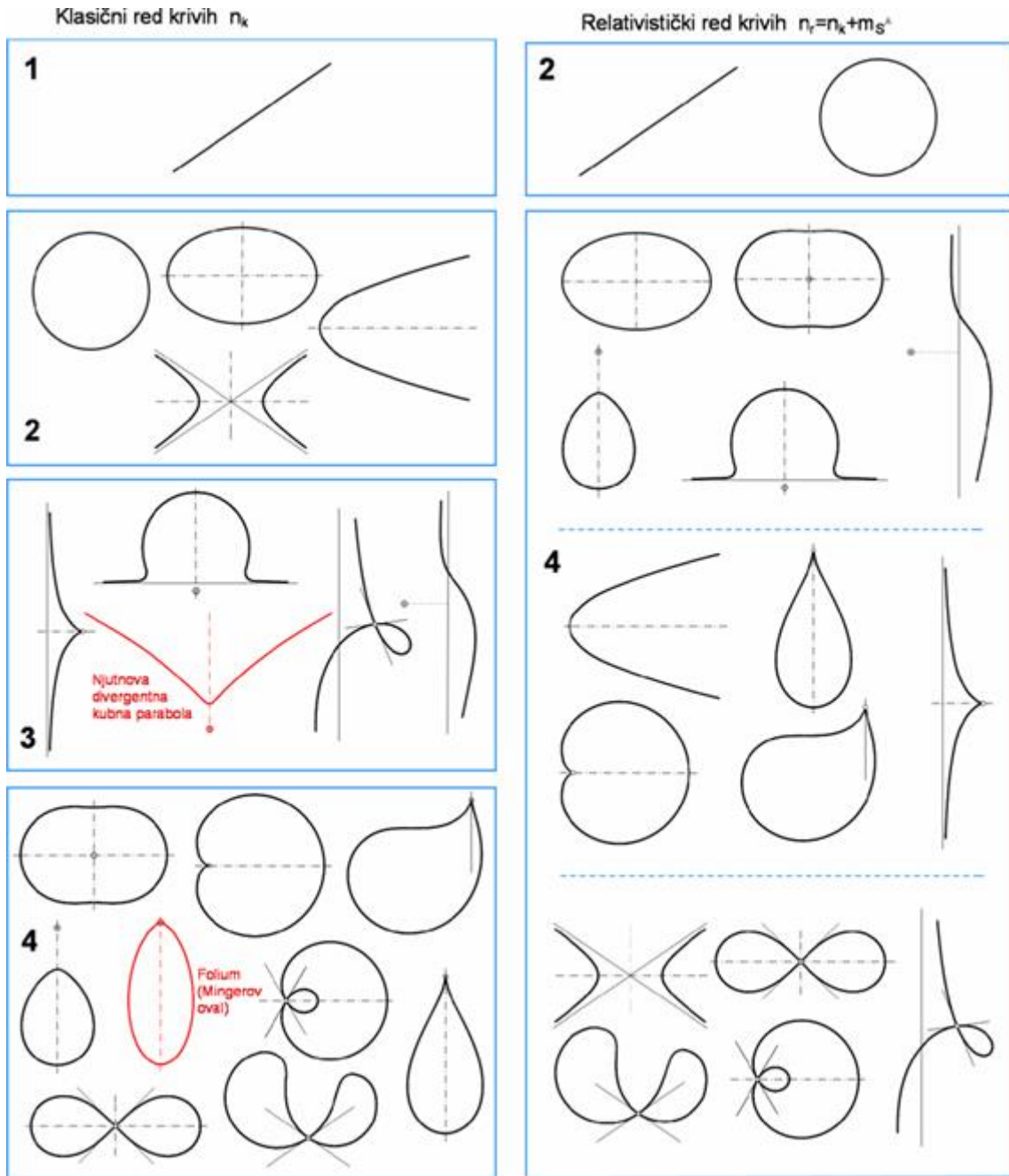


Fig. 2. Classical and relativistic order of curves

Three circles, marked 1, 2 and 3, are mapped into hyperbolas h_1 , h_2 and h_3 . Vanishing line v_1 intersects all the circles of the pencil, so all circles are mapped into hyperbolas using perspective collineation. The pencil of hyperbolas is parabolic-parabolic (homothetic hyperbolas) because it has two pairs of common points $1=2$ and $3=4$ at infinity, i.e. four points overlapping at the antipodal point. The disintegrated conic of the pencil is represented by two straight lines that intersect in S (SA and SB). Like mapping rays that pass through S , they are mapped into themselves. The mapped points \bar{A} and \bar{B} are at the observer's antipode. The asymptotes of all hyperbolas are parallel to these rays. A

Lisp routine was written to draw the hyperbola [7]. For that purpose, the UCS (user coordinate system) is inserted into the centre of the hyperbola. The parameters a and b of the hyperbola are loaded, with the condition that the minimum value along the axis x must be a , and the maximum value along the axis x is set at 150 mm (or more). A step of 0.5 mm is set to obtain the required quality of curve smoothness. To follow the mapping of hyperbolas, they are coloured with three different colours.

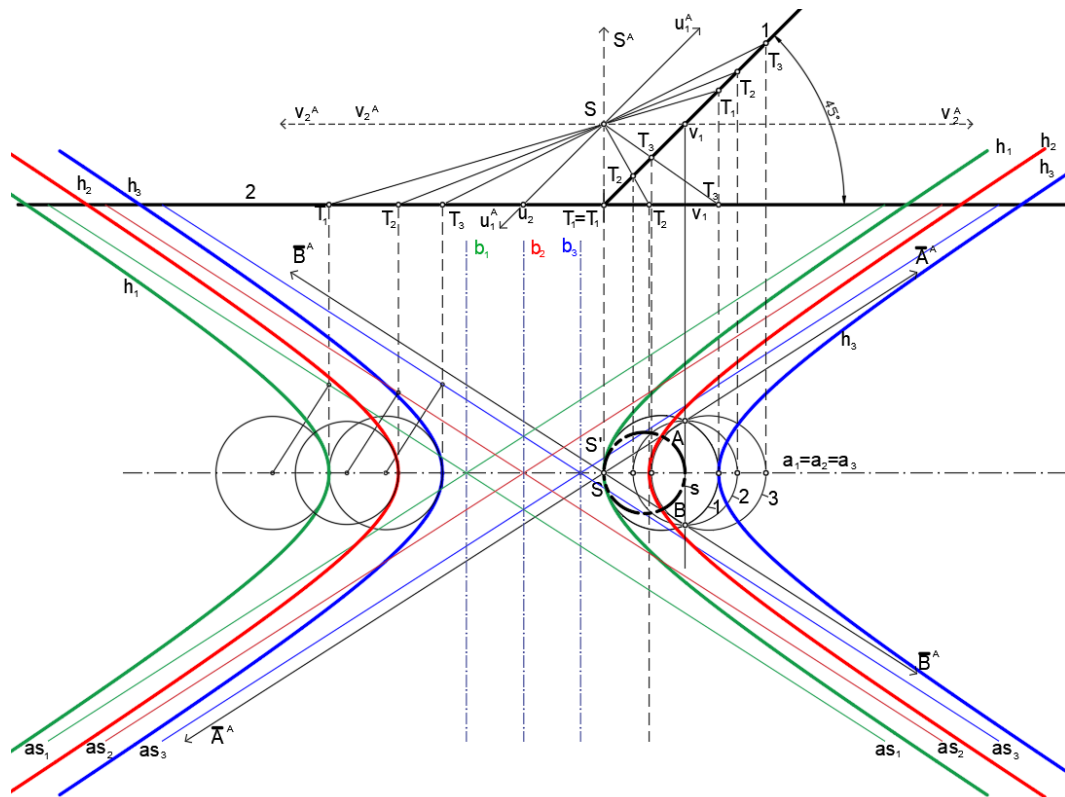


Fig. 3. Parabolic-parabolic pencil of hyperbolas

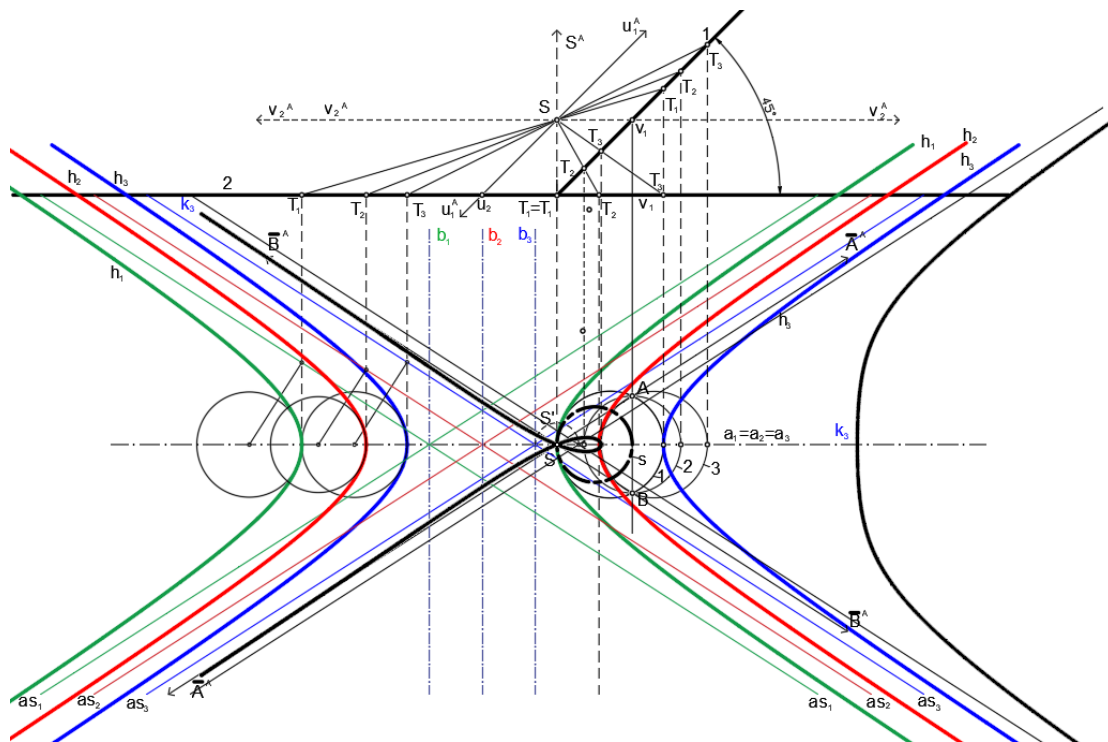


Fig. 4. Mapping of hyperbola numbered 3 into a curve of the eighth order (S, s)

A Lisp program was written for drawing the mapped curves using nonconformal symmetry. First, the hyperbola numbered three was mapped into the curve of the eighth order (S,s) [6]. The program was run by placing the UCS at the centre of symmetry S, loading the radius of the absolute and simply clicking on the curve to be mapped. To write the program for symmetry mapping, we created mathematical equations for the coordinates of the mapped points using the UCS coordinate system in centre S [10]. The following equations for the coordinates of the mapped points $\bar{P}(\bar{x}, \bar{y})$ were used

provided that the mapped point is P(x,y) [5]:

$$\bar{x} = \frac{4rx^2}{x^2 + y^2} - x \qquad \bar{y} = \frac{4rxy}{x^2 + y^2} - y$$

Applying axial symmetry, the mapping of points is performed simply by shifting the distance between point P and circular axis s to the other side in the direction of the centre of symmetry S.

Fig. 5 shows simple axial symmetry obtained by mapping points named M₁ and N₁. The points are in plane 1 and are mapped by perspective collineation through the centre S into plane 2 (points M₂ and N₂). Points M₁' and M₂' are then at the base point (for centre S and inversion circle s_s) inverted into points M₁ and M₂. Points N₁' and N₂' are also inverted into points N₁ and N₂. The points on the absolute which are used to shift the distance of the points from the absolute to the other side of the centre S are marked with the red letter C for M₁ and M₂ and with the blue letter C for N₁ and N₂. The large blue semicircle shows the obtaining of point M₂ by mapping symmetry mapping from point M₁. The smaller blue semicircle shows obtaining of point N₂ by mapping point N₁. The radius of the absolute - s in axial symmetry is equal to half the radius of the circle of inversion - s_s, and the centres of S for inversion and symmetry coincide [9].

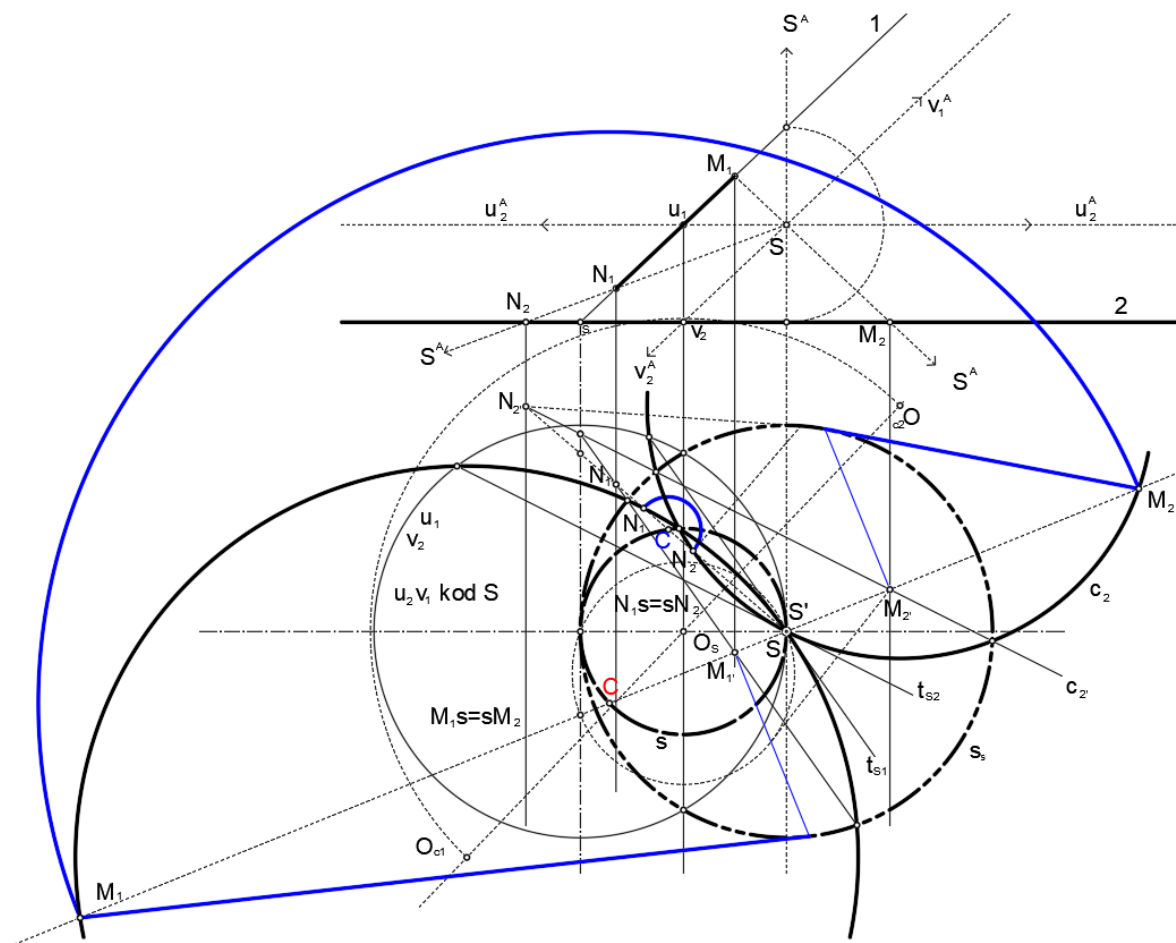


Fig. 5. Symmetry mapping of the points for center S and circular axis s (S, s)

By nonconformal symmetry, a pencil of hyperbolas is mapped into a pencil of curves of the eighth order (Fig. 6). In relativistic geometry, the hyperbola is of the fourth order ($2+2A$), while the obtained curve belongs to the eight order ($6+2A$) with a double point in S . The double point in the antipodal centre of symmetry is common to both curves, and therefore their corresponding asymptotes are parallel. In Fig. 7, a pencil of curves of the eighth order is mapped into a pencil of curves of a higher order. There are no more infinite points in the pencil and everything unfolds before the eyes of the observer [1].

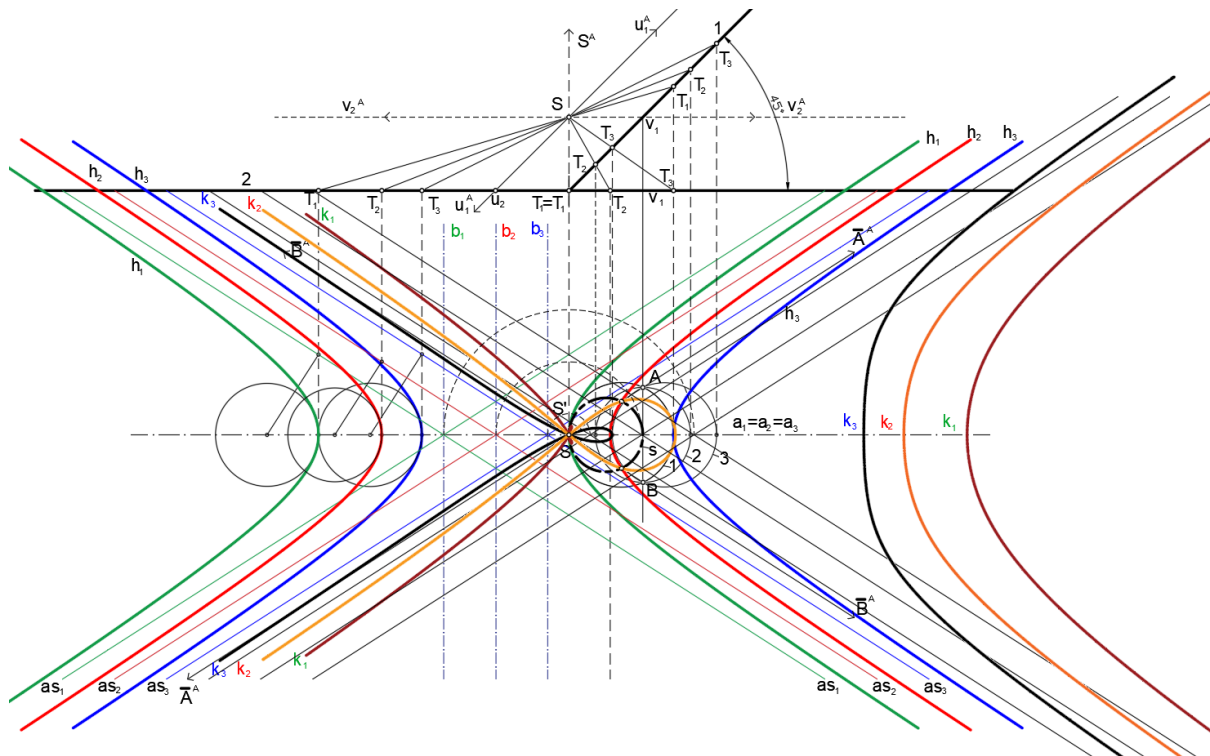


Fig. 6. Mapping of a pencil of hyperbolas into a pencil of curves of the eighth order (S, s) (relativistic order)

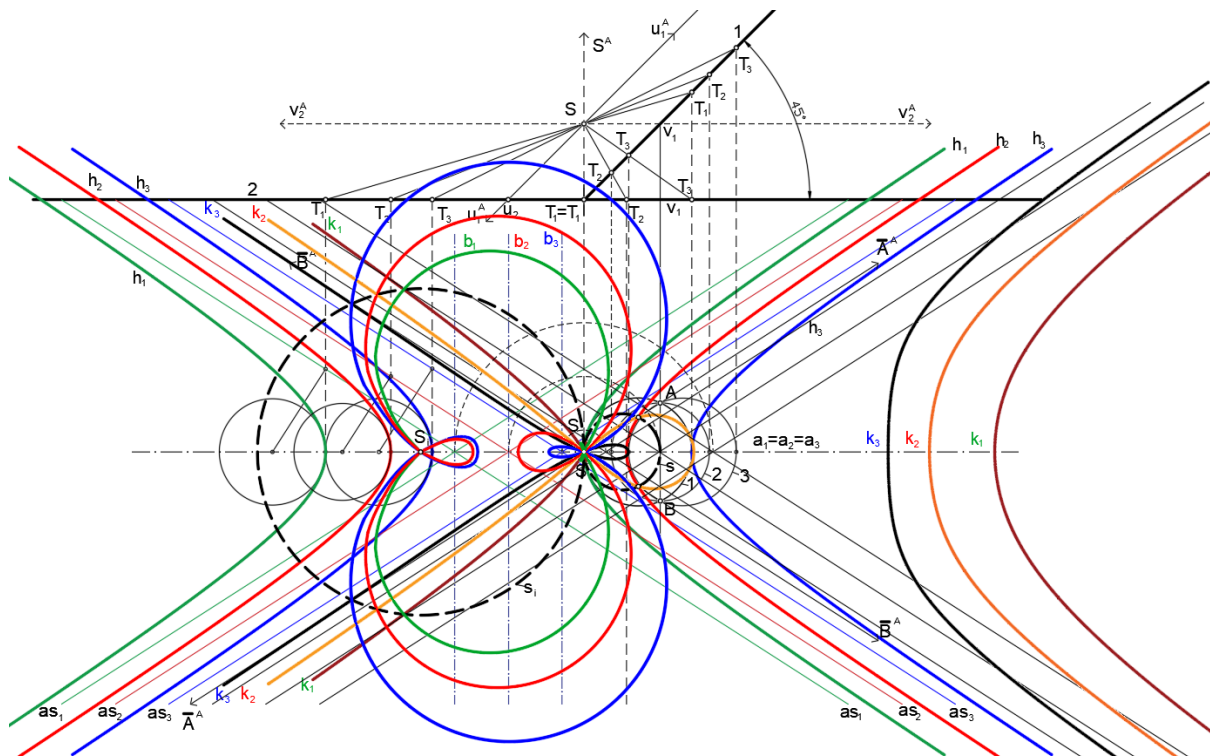


Fig.7. Inversion mapping of a pencil of curves of the eighth order into a pencil of curves of a higher order (S_i, s_i)

2.2 Elliptic-parabolic (EP) pencil of conics

In the following example (Fig. 8), an elliptic pencil of circles, which is placed towards vanishing line v_1 , is mapped by homology (perspective collineation) into a pencil of conics that contains an ellipse (circle 1 does not intersect the vanishing line), a parabola (circle 2 touches the vanishing line), a hyperbola (circle 3 intersects the vanishing line). The angle between planes 1 and 2 is 45° . By perspective collineation, a pencil of conics is obtained from an elliptical pencil of circles. This pencil of conics is elliptic-parabolic (EP) because it has two real and separated points in (A and B) and two infinite, i.e. two overlapping points at the antipodal point.

The disintegrated conic of the pencil is represented by two straight lines that intersect in S ($S_{\bar{A}}$ and $S_{\bar{B}}$). They map into themselves like mapping rays.

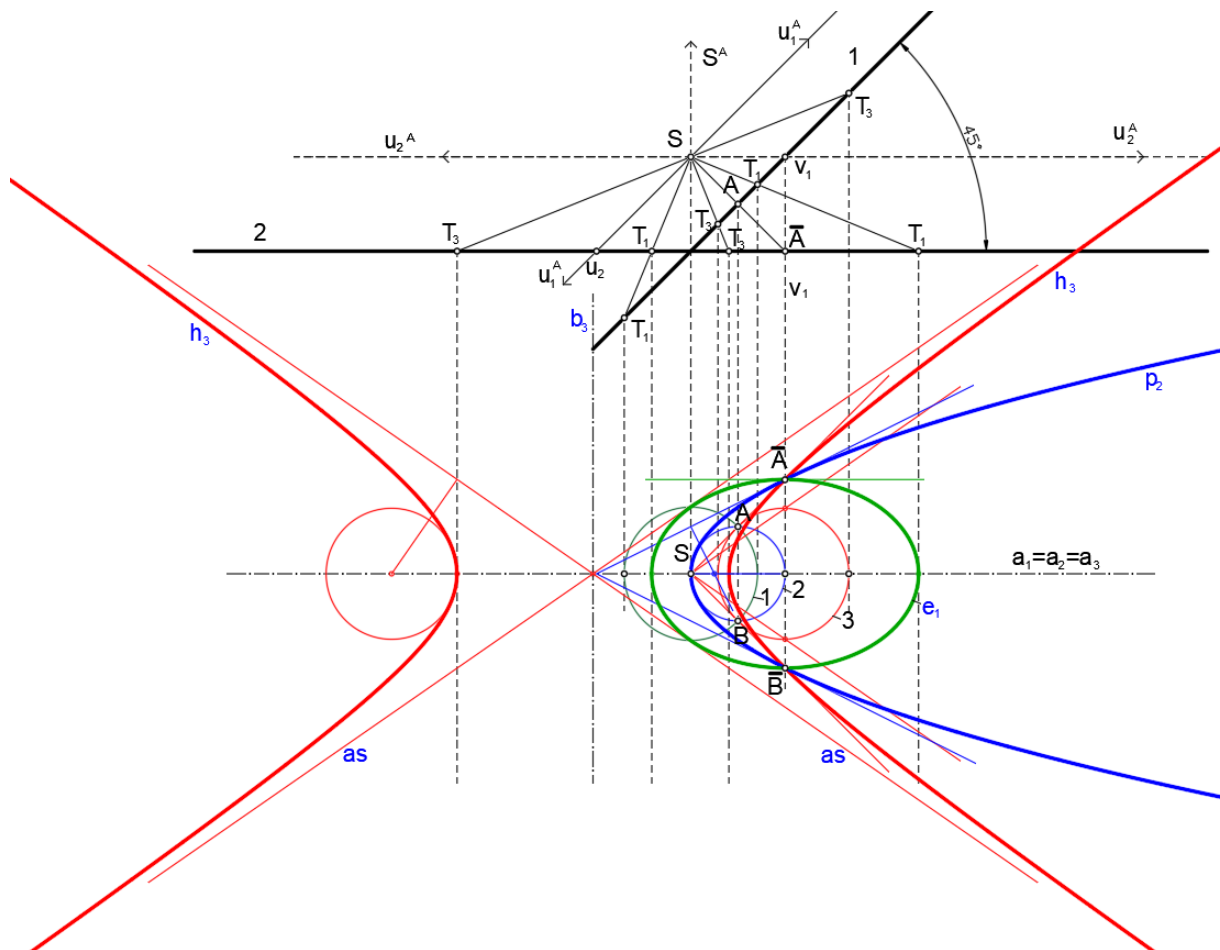


Fig. 8. Elliptic-parabolic (EP) pencil of conics

By nonconformal symmetry (Fig. 9) for the centre S and the circular axis s , we produced a pencil of mapped curves of the eighth order (relativistic order). This pencil contains elliptic, hyperbolic and parabolic curves. The points \bar{A} and \bar{B} and are mapped into point S . All the curves have two common overlapping points in S , and two points are at the antipode. The hyperbola maps into an eighth-order curve with a pair of asymptotes parallel to the asymptotes of the starting hyperbola. Only the centre is mapped by supersymmetry, which is shown by a semicircle with a dashed line.

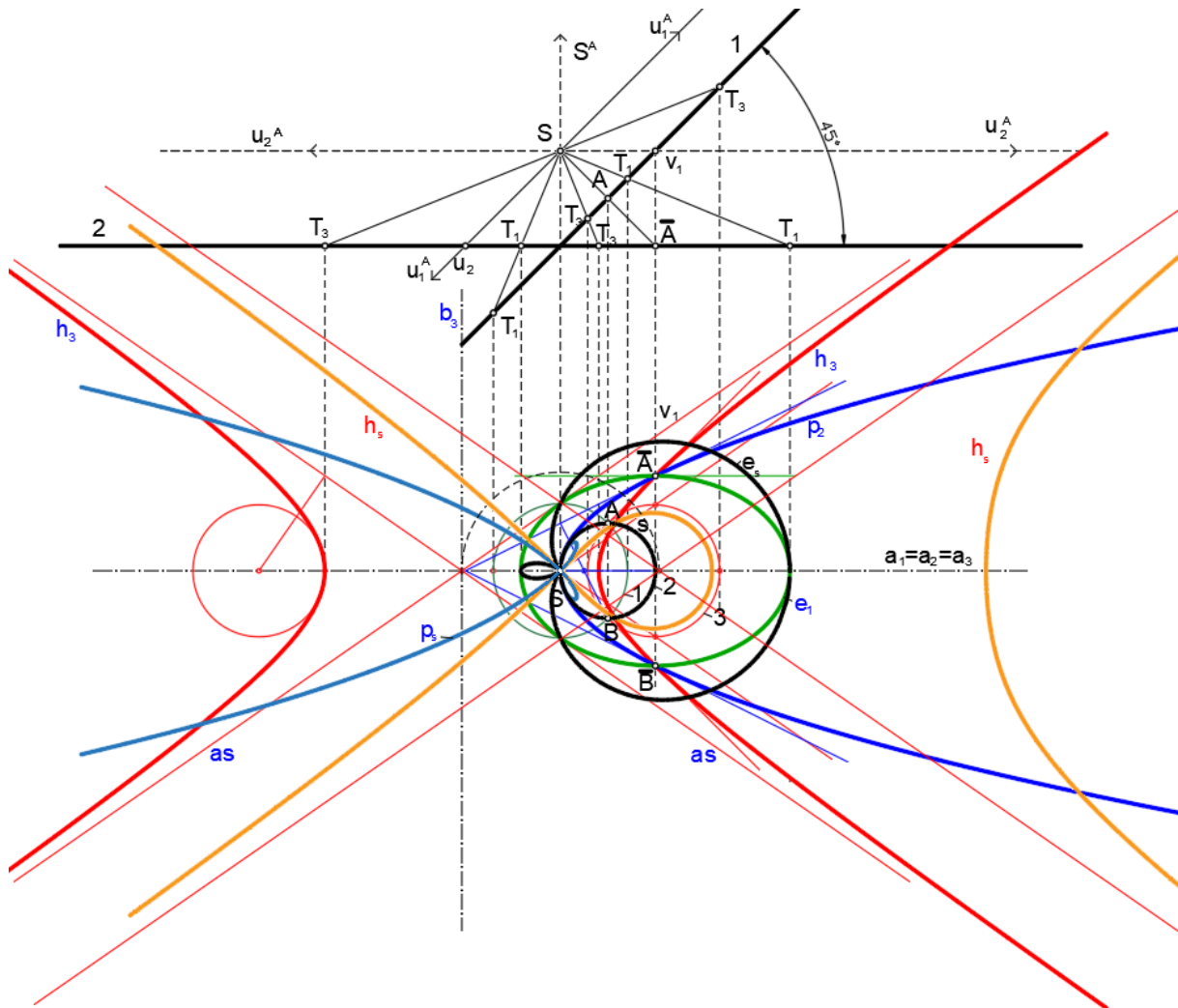


Fig. 9. Mapping of EP pencil of conics into EP pencil of curves using nonconformal symmetry for the center S and the circular axis s

3 CONCLUSIONS

This The three most important symmetries according to Dovniković L.:

- Relativistic inversion (conformal) was applied in the paper to obtain a pencil of higher-order curves.
- Relativistic harmonic homology (nonconformal) was applied to map pencils of circles.
- Supersymmetry i.e. inverted harmonic homology (nonconformal), which is the subject of this paper. It was used to map the pencils of the conics.

Recognizing the equivalence of inversion with classical axial symmetry (nonconformal symmetry) pointed to unlimited possibilities for mapping curves and obtaining new shapes that will be useful in the theory of geometry. Research in the area of symmetry will continue, which provides an inexhaustible space for further discoveries about planar and spatial curves. Curves can be mapped multiple times by symmetry, and all resulting curves will have the same properties as the original curve and will provide a wealth of desired shapes.

The nonconformal symmetry in relation to the circle, as an inverse image of the relativistic homology, enables us to perform the process of tying and untying of singular points, which in homology (by projecting the vanishing line into the antipodal circular point) ended in the "infinitely" distant antipode. It is now performed before the eyes of the observer (Fig. 7). Unlike inversion as conformal symmetry, which changes only the shape of the curve and nothing more, non-conformal symmetry can (but may not) change almost everything related to the number and type of singular points [8].

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