

## A set of programs for the study of light scattering on round diamonds

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To date, there is no theory of light scattering on diamonds of various shapes. As a rule, jewelers came to the available forms of diamonds in an experimental way. Moreover, these experiments lasted hundreds of years. And only at the beginning of the twentieth century, or rather in 1919, Marcel Tolokowsky [1] analyzed the course of a separate beam in a round diamond and found a condition when a beam, after several complete internal reflections, leaves the diamond crown.

With the advent of computers, it became possible to conduct a study of light scattering on crystals in more detail. The author of this complex of programs at the end 80s of the last century proposed a computational method for describing the scattering of light on atmospheric hexagonal crystals. It is based on two known methods: the geometric optics method and the physical optics method. Using the first, the path of the rays inside the crystal is built. Moreover, a system of algorithms is proposed, in framework of which all rays are combined into beams of parallel rays. For each beam, the magnitude of the electromagnetic field in its section, the direction of the beam leaving the crystal, as well as of its polygonal section is known. As a result, it is possible to integrate fields along of each light beam, that is, recalculate fields from the near zone to the far zone within the framework of the formalism of physical optics.

Light beams are easier to form from a part of front of a plane wave cut by a crystal, but from individual rays. Part of the front is distributed along the faces of the crystal, that is, it is divided into beams of parallel rays. Each beam partially passes into the crystal and is partially reflected from its face. Refracted beams pass through the volume of the crystal and are divided on its edges and vertices. With each new interaction of the beams with the internal interface, their further fragmentation occurs. Ultimately, the optical problem comes down to considering the scattering of a set of beams of parallel rays that have emerged from the crystal.

The proposed method was developed regardless of the shape of the crystal. Just set boundary conditions for it. When using geometric optics, boundary conditions here mean the equations of the planes on which the faces lie, as well as the numbers of the vertices belonging to the faces. These vertices form edges of faces. Finding face parameters requires the

development of non-obvious, so the geometric problem is independent interest and is highlighted in separate program.

As a result, the set of programs contains two programs: GeomCrys and OptCrys. Using the first GeomCrys program, the geometric parameters of the crystal for optical problem are determined. The second program OptCrys solved the optical problem.

### Working with the program GeomCrys

The program GeomCrys is loaded using the command line “java GeomCrys”, which is located in the batch file GeomCrys.bat. Class GeomCrys is a base class and works together with classes: CommInput, CaratCalc, FormDateMod and FinalFrame.

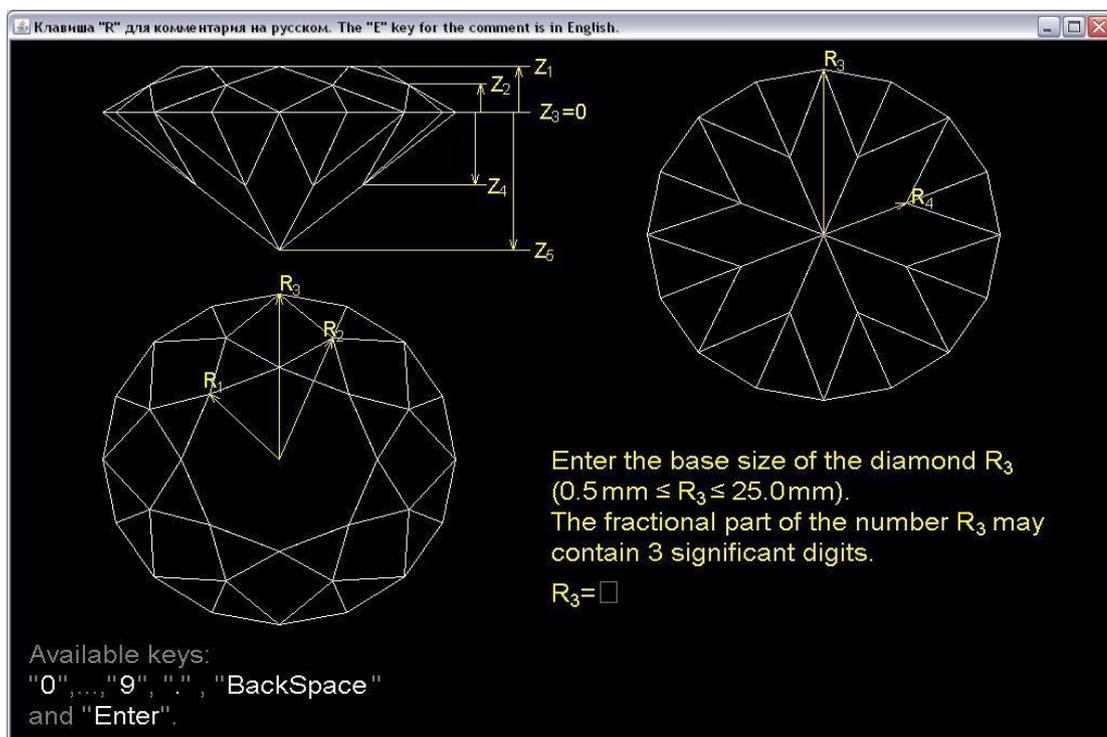


Fig.1. Window after the program is loaded.

The Figures 1 and 2 show the results of the class CommInput, which provides graphical input of values of parameter  $R_3$ . These figures show projections of a round diamond: left upper image – side view, left lower image – top view, right upper image – bottom view. It is easy to make sure that a round diamond can be set with 6 dimensions:  $Z_1, Z_2, Z_4, Z_5, R_1, R_3$ . Value  $Z_3=0$ . The remaining dimensions  $R_2$  and  $R_4$  are not free, but depend on the first 6 in such a way that quadrilateral faces are obtained.

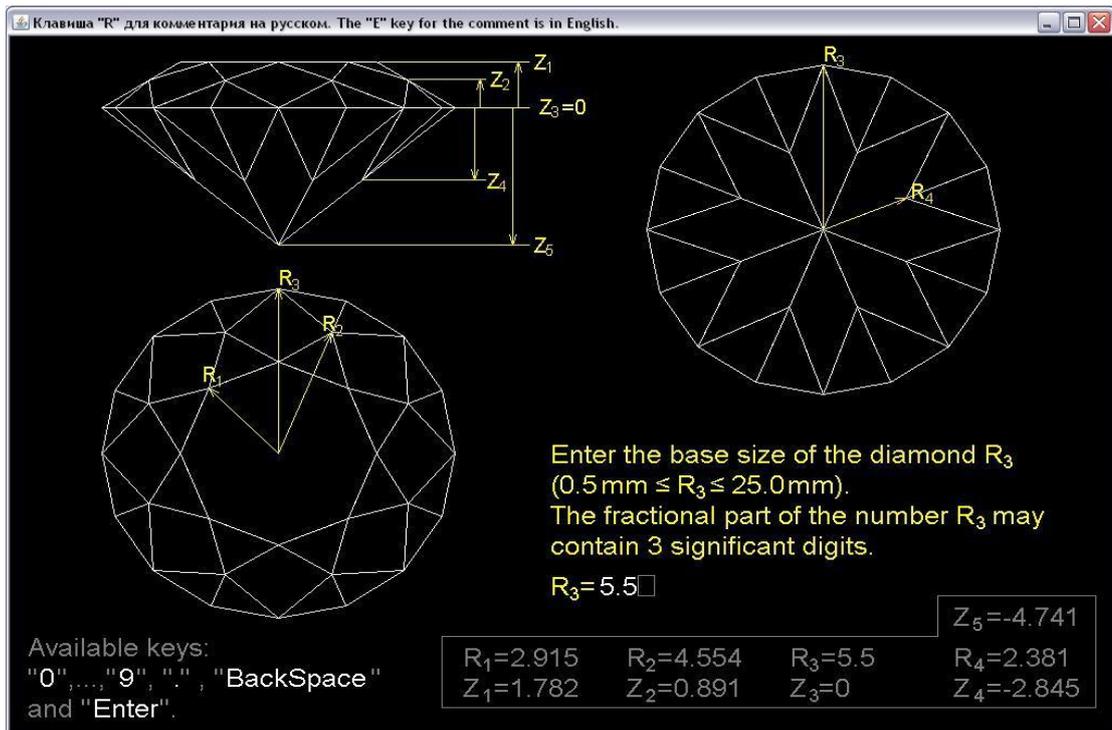


Fig.2. Window when entering a base dimension.

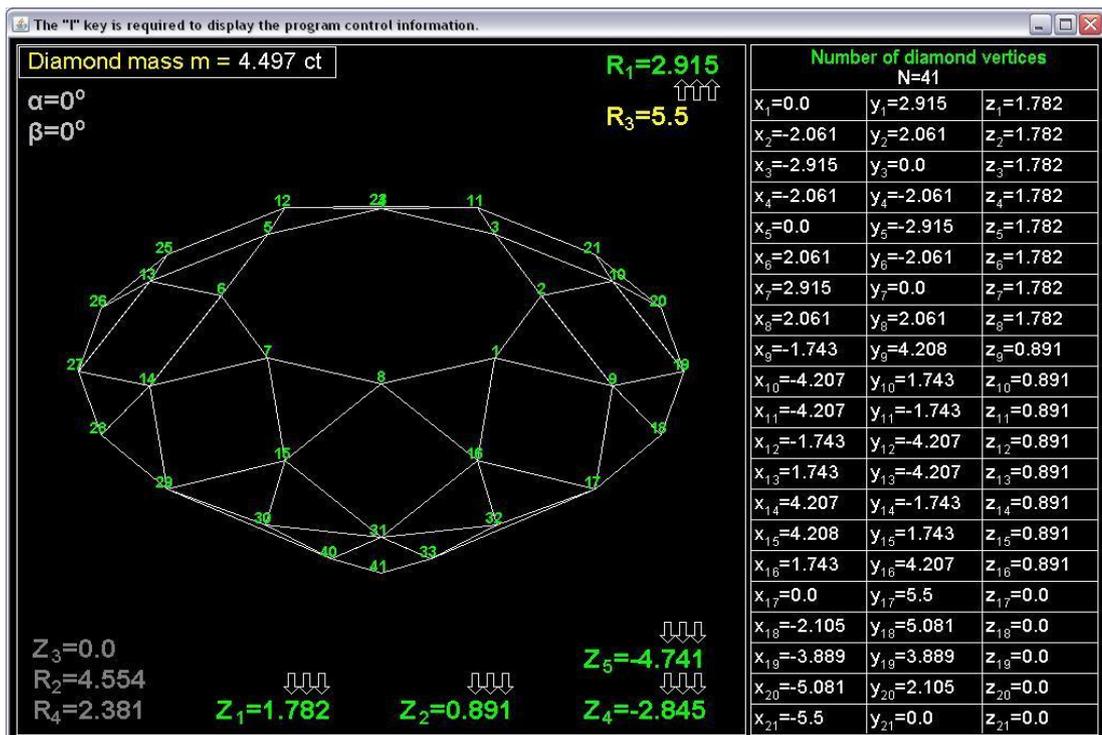


Fig.3. Go to this page after pressing the Enter key.

For circular diamond shape, its upper part, called the crown, contains 33 faces. Moreover, in the crown, the horizontal face is a regular octagon. The lower part of diamond, called pavilion, contains 24 faces. The magnitude  $R_3$  is the maximum radius in the diamond crown and in its pavilion. This value can be entered to an accuracy of 0.001 mm, that is, to an accuracy of  $1\mu\text{m}$ . Entering  $R_3$  immediately calculates the remaining

diamond dimensions according to the proportions for the so-called ideal shape.

After pressing the “Enter” key, the program calls the next page (Figure 3). It shows on the right the coordinates of 21 vertices from a table containing 41 vertices diamond. You can move to the other vertices after pressing “Page Down” key.

This page contains the main actions with the program, which are detailed in the displayed comment (Figure 4). For this page, the base class uses classes FormDateMod and CaratCalc.

The "I" key is required to display the program control information.

Diamond mass  $m = 4.497$  ct

$\alpha = 0^\circ$   
 $\beta = 0^\circ$

$R_1 = 2.915$   
 $R_3 = 5.5$

- You can delete a comment by pressing the "I" key again.
- Use the "Home" key to move directly and backwards from the table with coordinates of the diamond vertices to the table with parameters of the equations of the planes of its faces.
- Uses the "PgUp" and "PgDn" keys to navigate to neighboring pages in tables.
- The ←, →, ↓ and ↑ keys are required to change the rotation angles of the diamond  $\alpha$  and  $\beta$  in two perpendicular planes.
- Use the ← and → keys to change the linear size of the diamond after activating the arrow associated with this dimension.
- The arrow is **activated** when mouse clicks when the pointer is over the arrow.
- The arrow is **deactivated** when you click a window field does not contain arrows.
- When pressing the "C" key, there is a direct and reverse transition from the current page to the page with the results of calculations of the volume of this form of diamond and its mass in carats.
- Pressing the "S" key saves the data for the current diamond shape.

$Z_1 = 1.782$     $Z_2 = 0.891$     $Z_4 = -2.845$

$R_2 = 4.554$     $R_4 = 2.381$

Number of diamond vertices  
N=41

$x_1 = 0.0$	$y_1 = 2.915$	$z_1 = 1.782$
$x_2 = -2.061$	$y_2 = 2.061$	$z_2 = 1.782$
$x_3 = -2.915$	$y_3 = 0.0$	$z_3 = 1.782$
$x_4 = -2.061$	$y_4 = -2.061$	$z_4 = 1.782$
$x_5 = 0.0$	$y_5 = -2.915$	$z_5 = 1.782$
$x_6 = 2.061$	$y_6 = -2.061$	$z_6 = 1.782$
$x_7 = 2.915$	$y_7 = 0.0$	$z_7 = 1.782$
$x_8 = 2.061$	$y_8 = 2.061$	$z_8 = 1.782$
$x_9 = -1.743$	$y_9 = 4.208$	$z_9 = 0.891$
$x_{10} = -4.207$	$y_{10} = 1.743$	$z_{10} = 0.891$
$x_{11} = -4.207$	$y_{11} = -1.743$	$z_{11} = 0.891$
$x_{12} = -1.743$	$y_{12} = -4.207$	$z_{12} = 0.891$
$x_{13} = 1.743$	$y_{13} = -4.207$	$z_{13} = 0.891$
$x_{14} = 4.207$	$y_{14} = -1.743$	$z_{14} = 0.891$
$x_{15} = 4.208$	$y_{15} = 1.743$	$z_{15} = 0.891$
$x_{16} = 1.743$	$y_{16} = 4.207$	$z_{16} = 0.891$
$x_{17} = 0.0$	$y_{17} = 5.5$	$z_{17} = 0.0$
$x_{18} = -2.105$	$y_{18} = 5.081$	$z_{18} = 0.0$
$x_{19} = -3.889$	$y_{19} = 3.889$	$z_{19} = 0.0$
$x_{20} = -5.081$	$y_{20} = 2.105$	$z_{20} = 0.0$
$x_{21} = -5.5$	$y_{21} = 0.0$	$z_{21} = 0.0$

Fig.4. Displays the program control instruction after pressing the “I” key.

Class FormDateMod provides a system of algorithms for finding planes on which faces lie and vertex numbers belonging to each face. Figure 5 on the right shows the table for the first 13 faces of 57. The remaining plane equations are displayed after pressing the “Page Down” key.

On this page, the top line shows the mass of the diamond in carats. The CaratCalc class calculates the volume of the current diamond shape in real time (Figure 6).

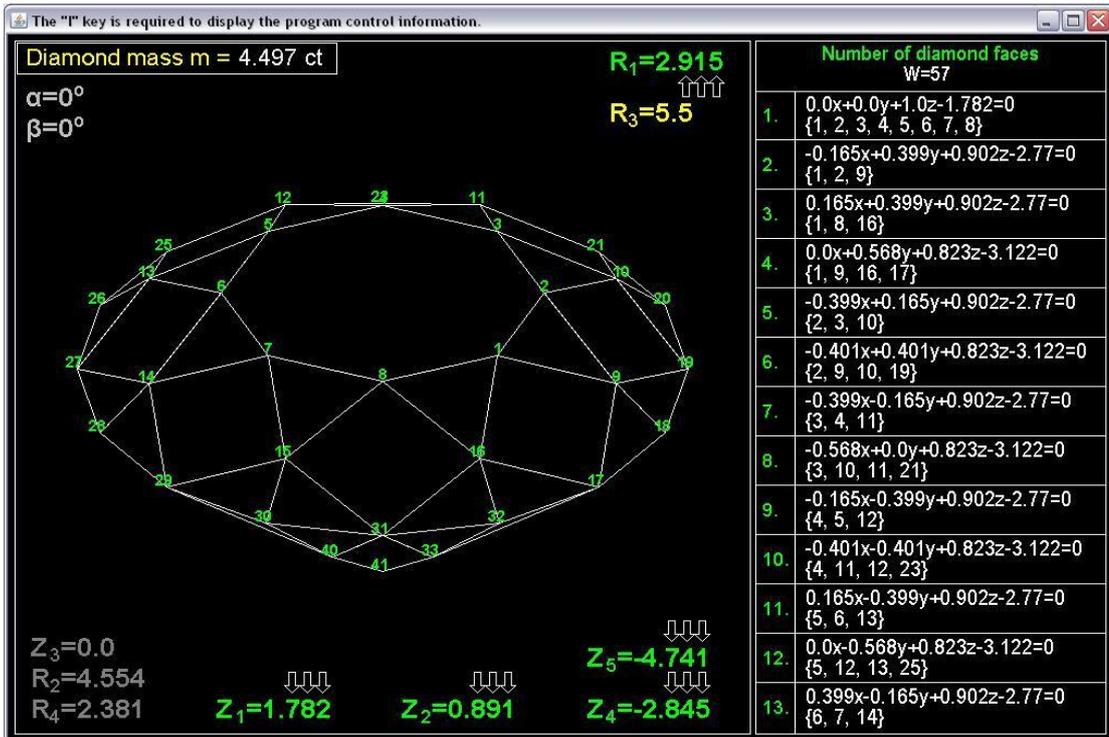


Fig.5. Replaces a table with vertex coordinates with a table with face plane relations after you press Home.

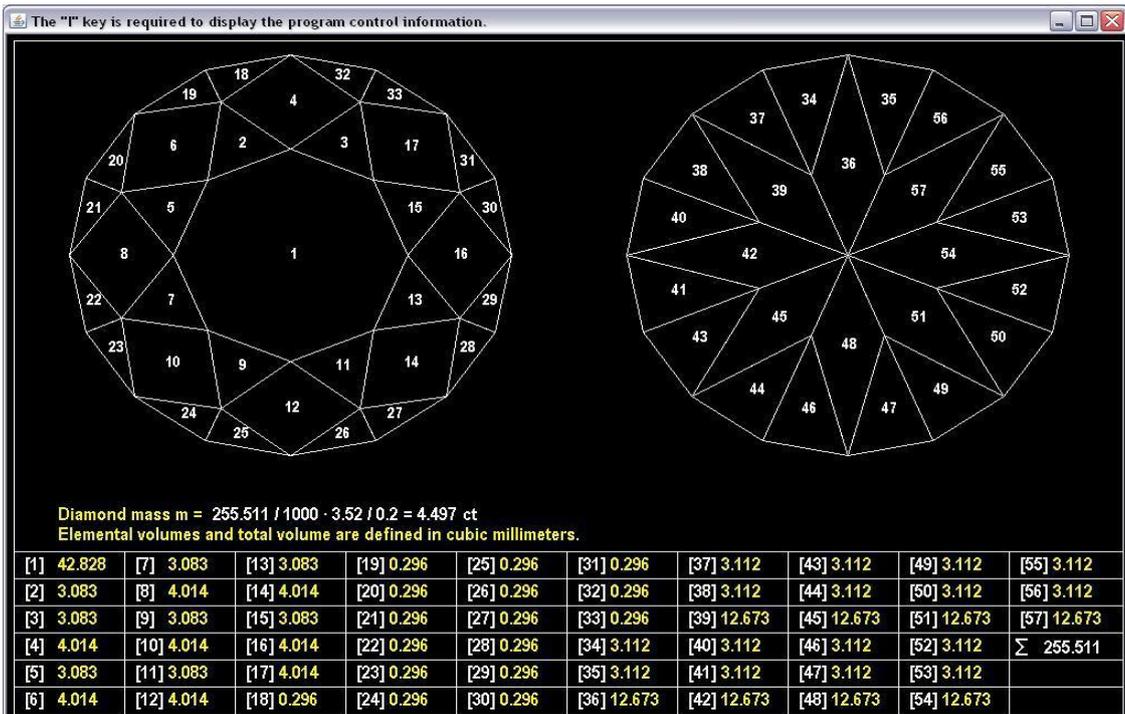


Fig.6. Integration areas for calculating diamond volume.

The areas shown in Figure 6 are projections of diamond faces onto the coordinate plane  $z=0$ . As a result, the triple integral breaks down the sum of 57 triple integrals. Each of the 33 integrals for the diamond crown is bounded above by a known face plane, and from below by a  $z=0$  plane. The remaining volumes for the diamond pavilion are bounded from the corresponding planes of the faces, and from above by the coordinate plane

$z=0$ . The results of volume calculations in cubic millimeters are shown in the table (Figure 6).

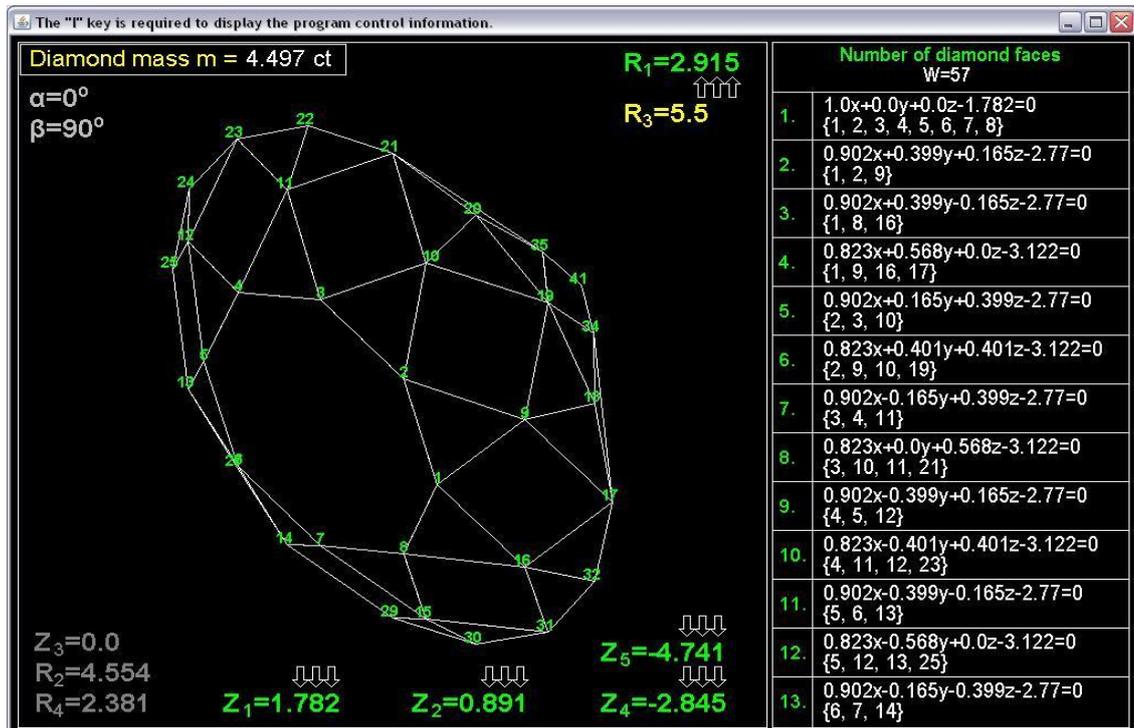


Fig.7. After each pressing of the "Up" key, the rotation angle  $\beta$  is increased by 1 degree.

In the upper row above the table (Fig. 6), the calculation of the mass of the diamond in carats with its known volume is given. The value of  $3.52 \text{ g/cm}^3$  is the density of the diamond, the coefficient of  $0.2 \text{ g}$  corresponds to one carat. A factor of 1000 translates cubic millimeters into cubic centimeters.

Figure 7 shows the intermediate position of the diamond as rotates, with which initially invisible faces and vertices are viewed. In this case, the angle  $\beta$  to  $90^\circ$  is changed by repeatedly pressing "Up" key. Each press of this key increases the angle  $\beta$  by  $1^\circ$ .

Pressing the "S" key displays a simple menu for saving data (Figure 8). After clicking on the left rectangle, the data is saved in the binary file  $vg_{**}.dat$ , the previous window is made invisible and a new window is displayed using the FinalFrame class (Figure 9). The base class GeomCrys automatically determines the sequence number of the file, which can vary from 01 to 99.

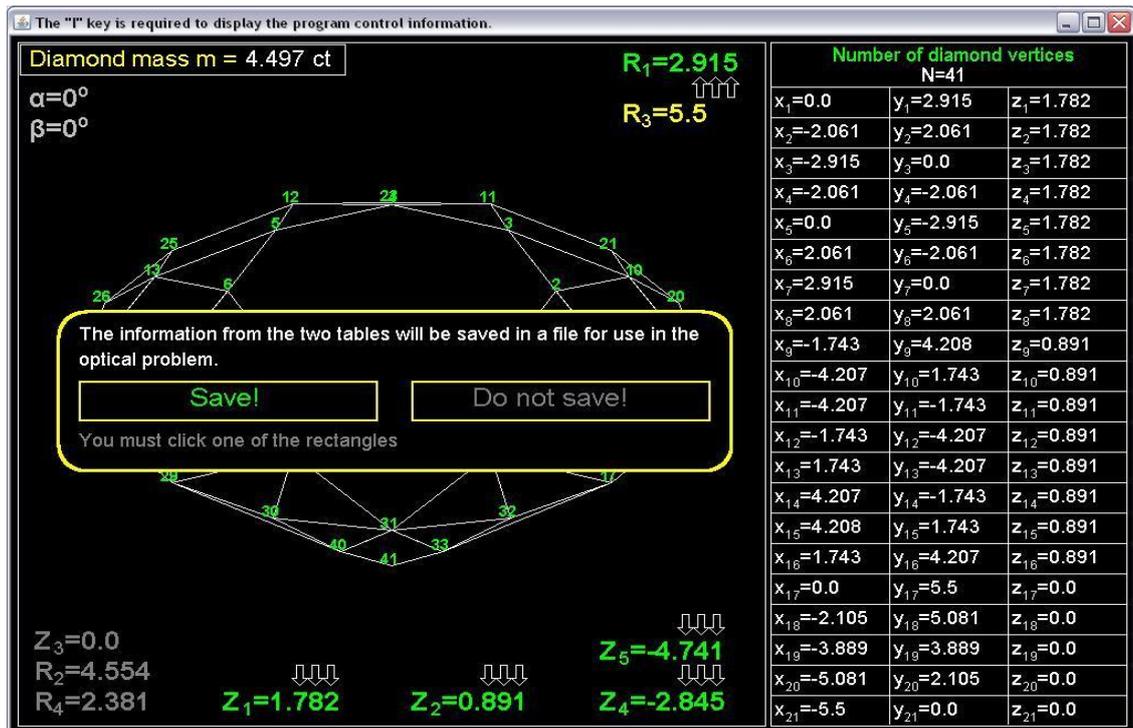


Fig.8. After pressing the "S" key, the program is put into data recording mode.

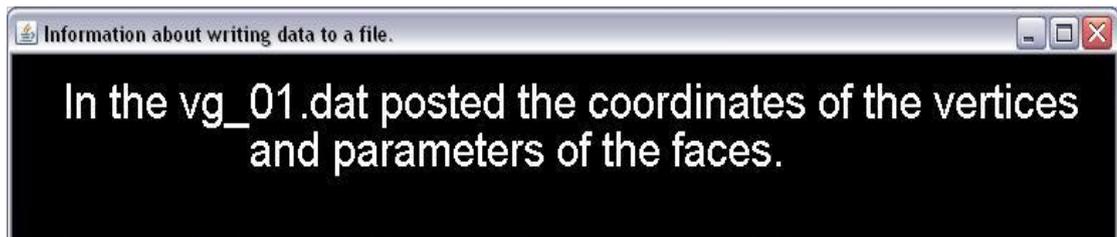


Fig.9. Information about the new data file.

In the main window of the program, you can change 5 sizes of the diamond. Each variable size is equipped with three arrows. The desired arrow is activated by clicking. As a result, you can change a size in steps 0.1, 0.01 or 0.001 by pressing the "Left" and "Right" keys.

In Figure 10, two dimensions  $Z_4$  and  $Z_5$  were changed to -3.6 mm and -3.792 mm, respectively.

As a rule, the height of the diamond crown is less than height of pavilion. As a result, the ideal shape of the diamond may not fit into the processed diamond along the height of the pavilion. Here, the height of the pavilion is deliberately reduced. However, the  $Z_5$  is not chosen arbitrarily, but so that the quadrangular faces of the crown and pavilion of diamond are parallel in pairs. The faces of the diamond crown with numbers 4, 6, 8, 10, 12, 14, 16, 17 are parallel to the faces of the diamond pavilion with numbers 48, 51, 54, 57, 36, 39, 42, 45.

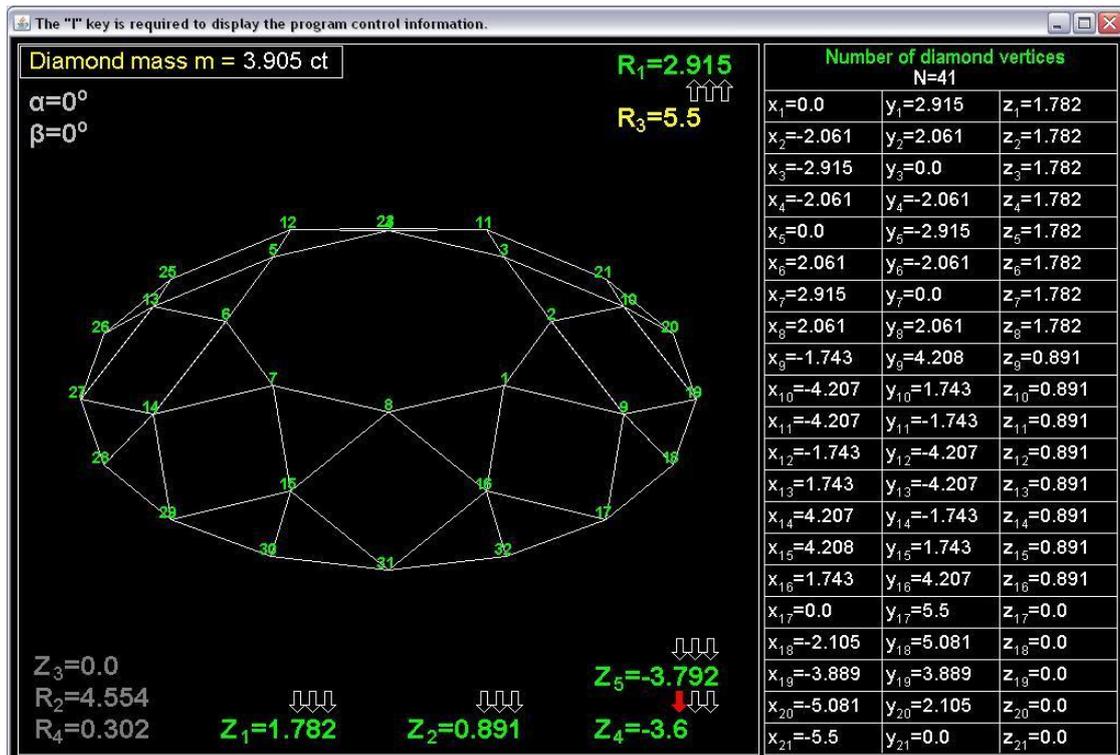


Fig.10. Decrease the height of the diamond pavilion.

With a size of  $Z_4 = -3.6$ , the quadrangular faces of the diamond pavilion become long and narrow.

### Working with the program OptCrys

This program is loaded using the command line "java OptCrys", which is located in the batch file OptCrys.bat. The program OptCrys uses 4 auxiliary classes: Complex and Dim\_Vect classes are similar to C structures and combine 2 and 3 real numbers, respectively, complex number operations are implemented in the CoOpFu class, the rrt class is necessary to calculate Fresnel coefficients. In addition to classes, the Complex class is used to describe a complex number, and the Dim\_Vect class is required to specify a vector or point in 3D space.

Figure 11 shows the initial window of the program after it is loaded. At an angle  $\beta = 180^\circ$ , the primary plane wave falls normally on the octagonal face of the diamond. Parameters in given frames can be changed: angles a pitch of  $1^\circ$ , real part of the complex refractive index with a pitch of 0.01, imaginary part of complex index by an order of  $0 \sim 10^{-10}$  to  $10^{-4}$ . At an angle  $\beta = 180^\circ$ , only 33 faces of the diamond crown are visible. The sum of their projections forms a geometric shadow. As a result, 33 reflected beams and 33 refracted beams are formed. The rays within each beam interact with one face, so their reflection and refraction are described by one reflection coefficient and one transmission coefficient.

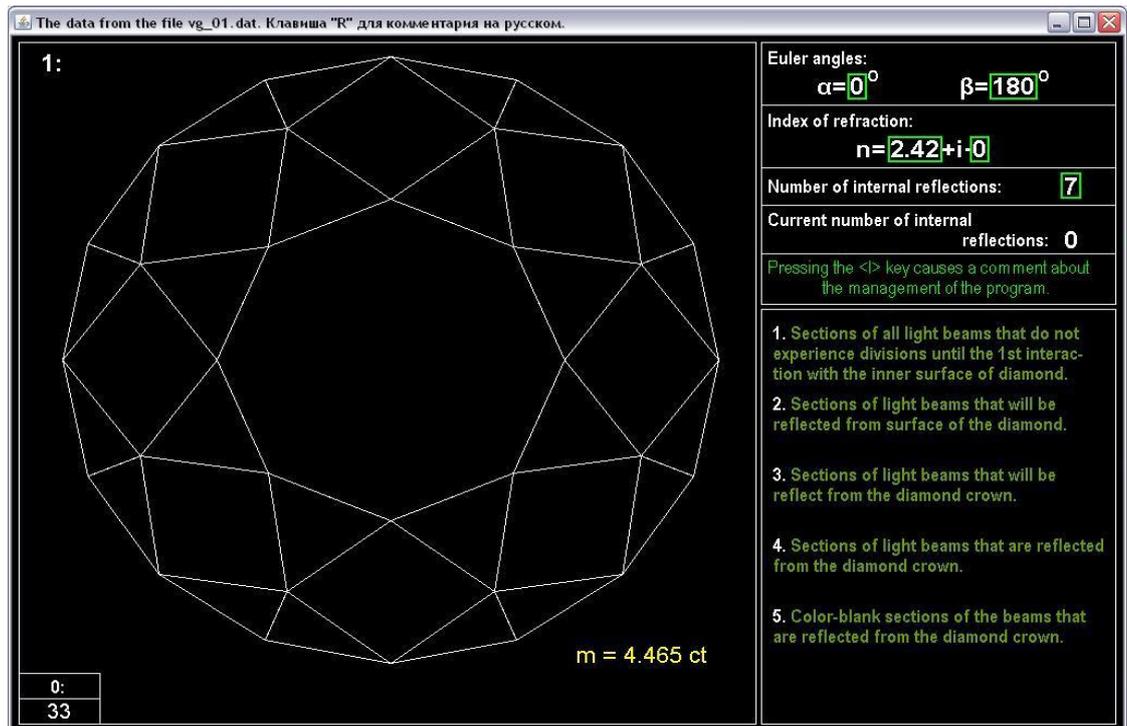


Fig.11. The initial window of the program OptCrys after it is loaded.

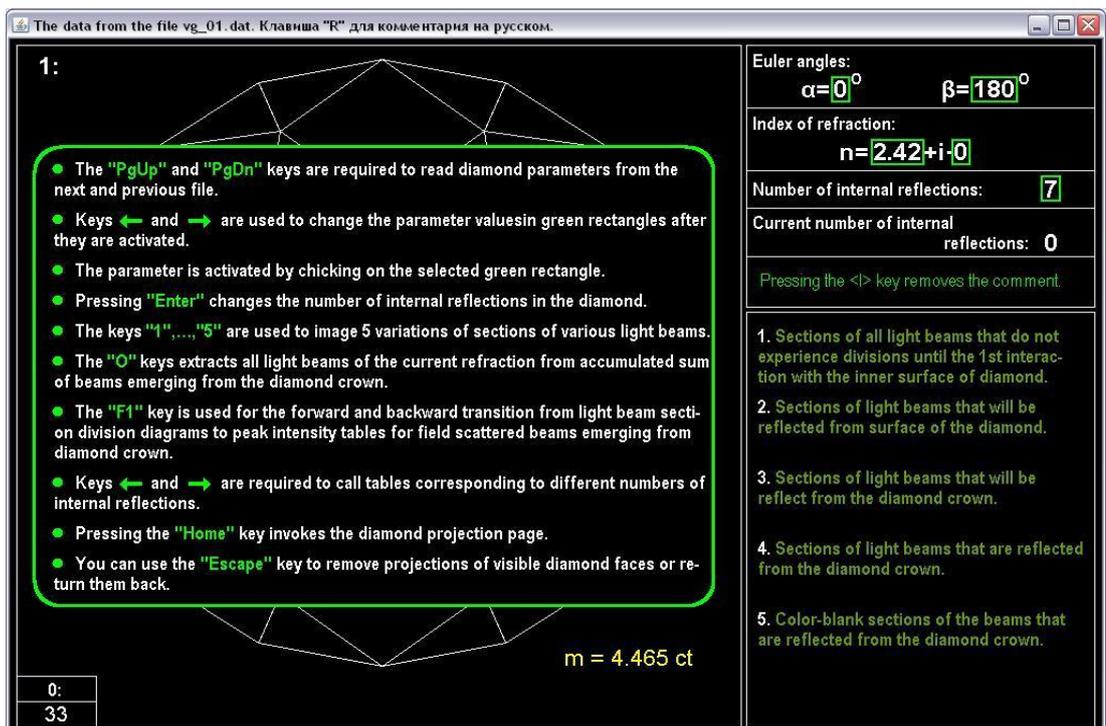


Fig.12. Displays the program control instruction after pressing the "1" key.

Figure 12 details the keys that control the program.

At the first pressing of the "Enter" key, 33 light beams after one passage through the volume of the diamond are divided into 128 beams, after two passes when pressing the "Enter" key again – by 416, after three – by 528 (Figure 13). Light beams formed during division are split into reflected and refracted beams. By default, the option shown in Figure 13

corresponds to a key pressed with the number 1 of the main keyboard. The number “1” is displayed in the upper left corner of the window.

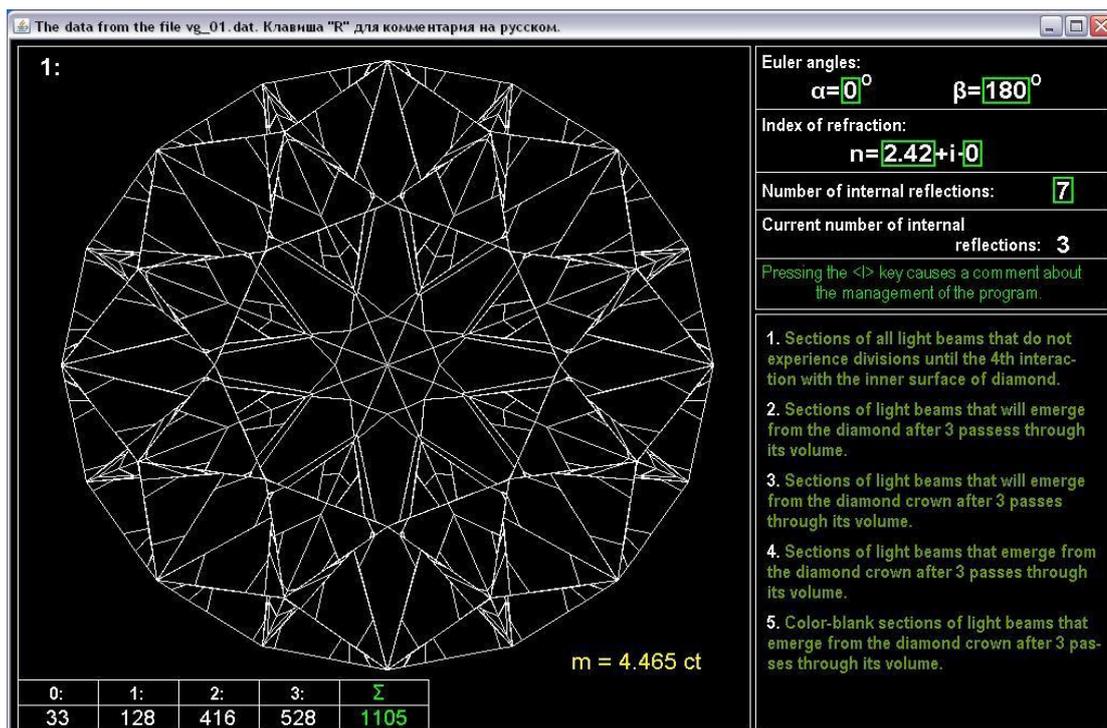


Fig.13. Sections of light beams formed after 3 divisions as a result of 3 pressing the Enter key.

Note that from most of the light beams obtained during the 3<sup>rd</sup> interaction with the inner surface of the diamond, beams are formed emerging from the diamond crown (Figure 14). Their number is 424.

If, after dividing, all light beams in the form of their sections can be assembled in place of the geometric shadow and continuously filled it, then the section of the out beams are superimposed on each other. The figure shows in dark blue beams reflected from the diamond, and in blue the beams that came out of his crown. Overlapping beam sections partially violates the symmetry of the output beam diagram. Figure 16 shows the profile diagram of the sections of the out light beams, obtained after pressing the “5” key. It is easy to make sure that the symmetry is preserved, but this diagram is less informative compared to the diagram shown in Figure 15.

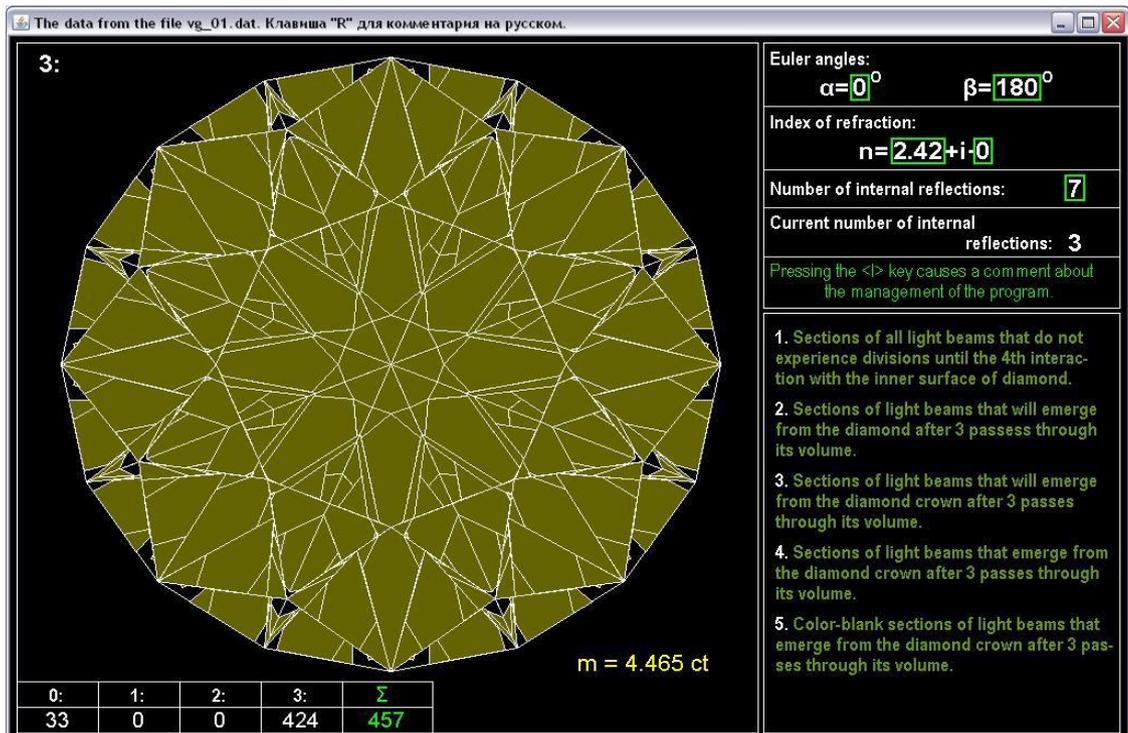


Fig.14. Section of light beams that will emerge from the diamond crown after one refraction, two reflections and another refraction.

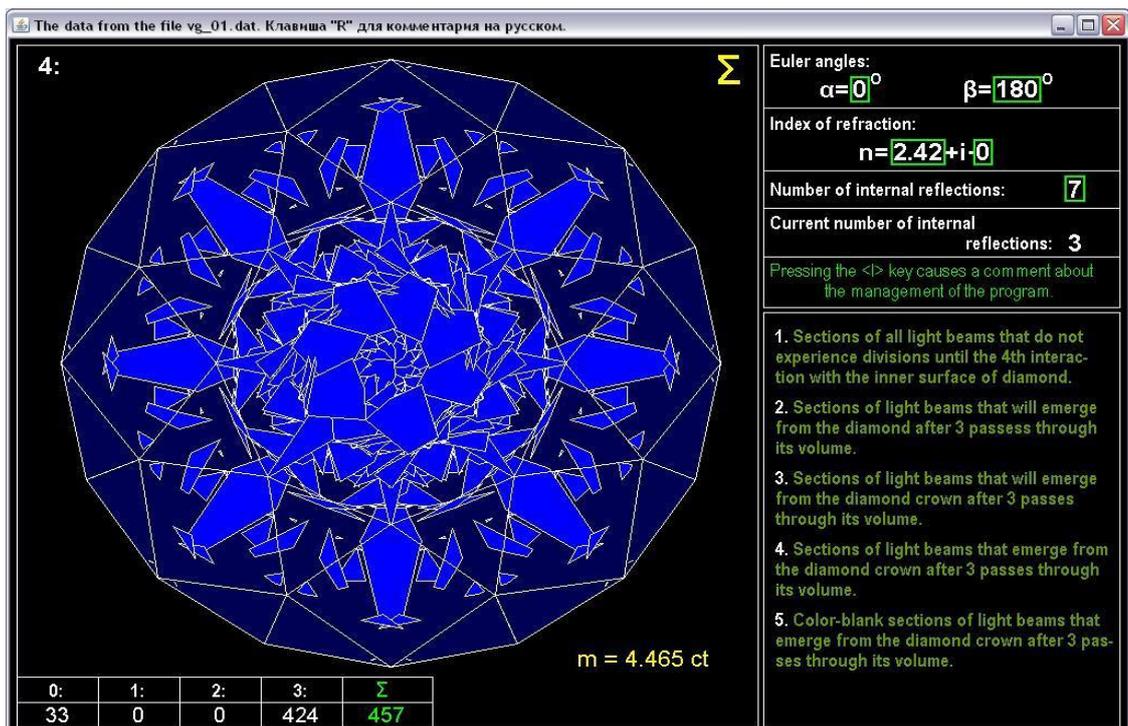


Fig.15. Sections of reflected and out of the crown diamond light beams after 3 divisions and 3 interactions with its faces.

Each light beam in the far area is converted into a spherical wave. For the visible part of the optical range, the far area can be considered as 1 meter and even 10 centimeters, since these distances are thousands of times the wavelength. Each spherical wave has an amplitude factor describing the degree of localization of field intensity near the light beam

exit from the crystal face. The degree of localization can be the width of the main lobe of the scattering pattern at the level of half peak intensity. For example, if the radius of the circumscribed circle around the regular octagonal section of the beam  $R=3$  mm, then at a wavelength of  $\lambda=0.55$   $\mu\text{m}$ , the width of the lobe  $\Delta\theta\sim 0.0057^\circ$ , if  $R=0.3$  mm, then  $\Delta\theta\sim 0.057^\circ$ , and  $\Delta\theta\sim 0.57^\circ$  at  $R=0.03$  mm. Thus, the intensity carried by the light beam is localized near the direction of its exit from the crystal, and in the very direction the intensity reaches its peak value [2, 3].

The beam concept provides a simple explanation of the play of light in a diamond. When the angle of vision changes, different sections of the diamond shine because at different viewing angles, different beams give a contribution to the overall intensity, which of different parts of its volume and at different angles.

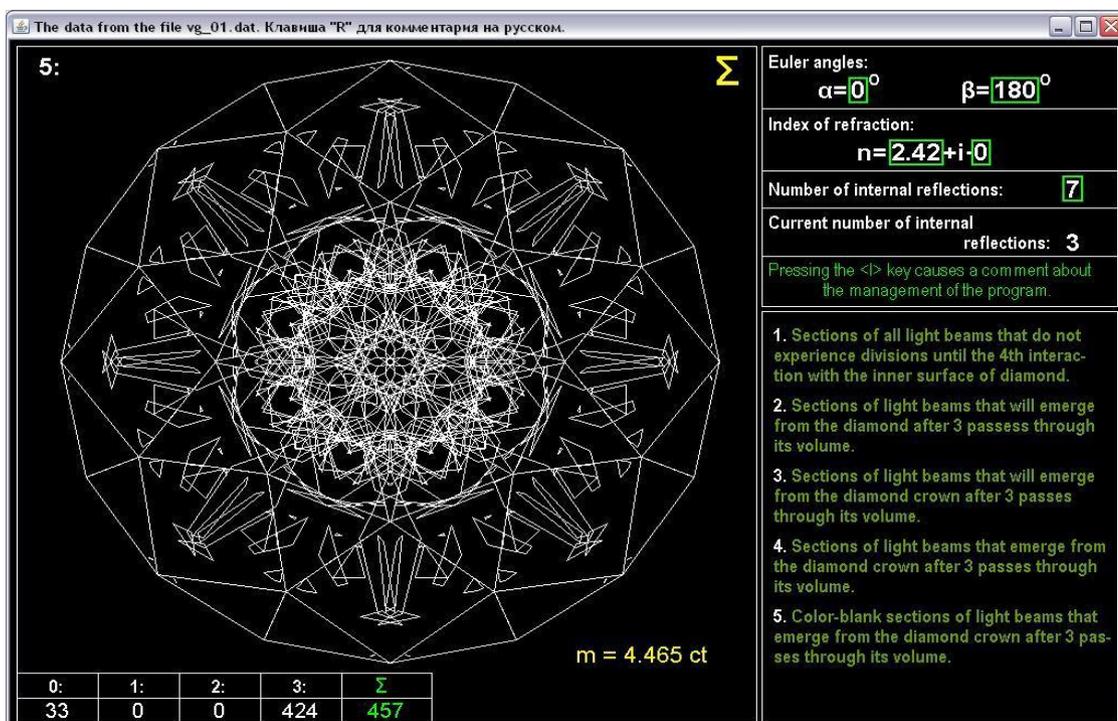


Fig.16. Check symmetry of the diagram of section of light beams emerging from the diamond crown.

After the 6<sup>th</sup> division, 2400 beams are formed (Figure 17). Their sections fit into the geometric shadow at the site of the sections 1712 beams, not crossing their borders, but forming new ones.

Figure 18 shows the sections of all light beams emerging from the diamond crown to the current 6<sup>th</sup> interaction with the internal boundary of the partition. 160 and 1168 sections are added to the exiting 424 sections (Figure 18). As a result, sections almost completely fill the diamond crown.

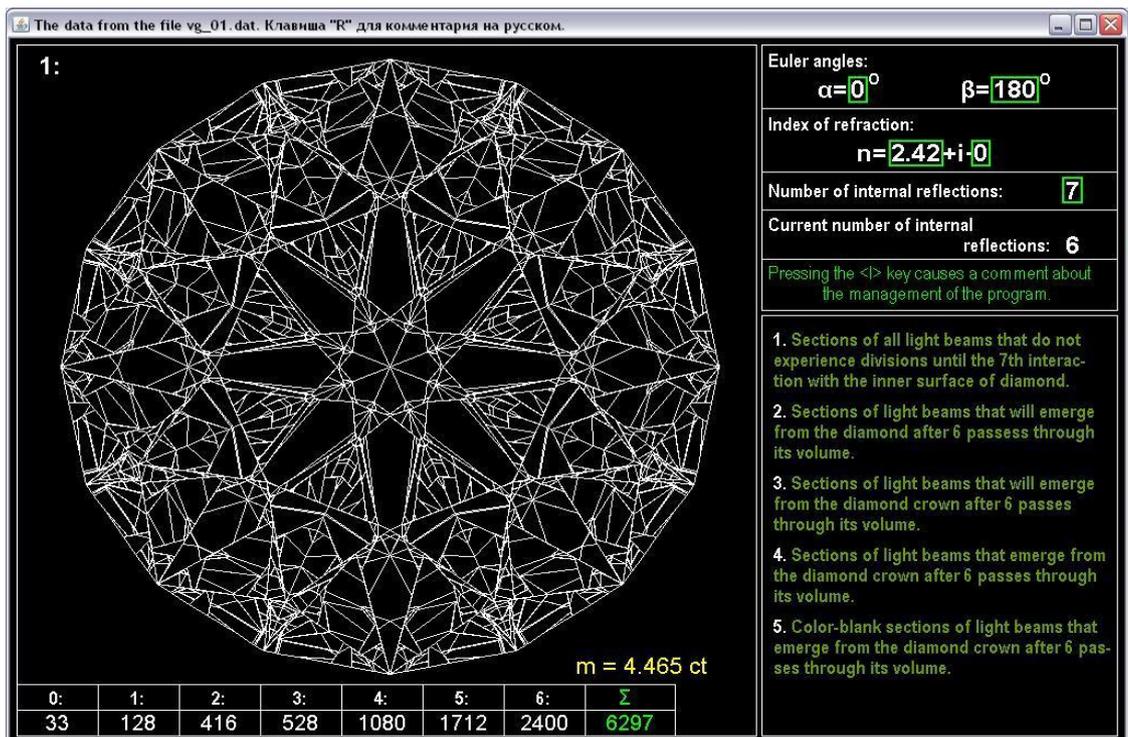


Fig.17. Sections of light beams formed after 6 divisions as a result of 6 pressing the Enter key.

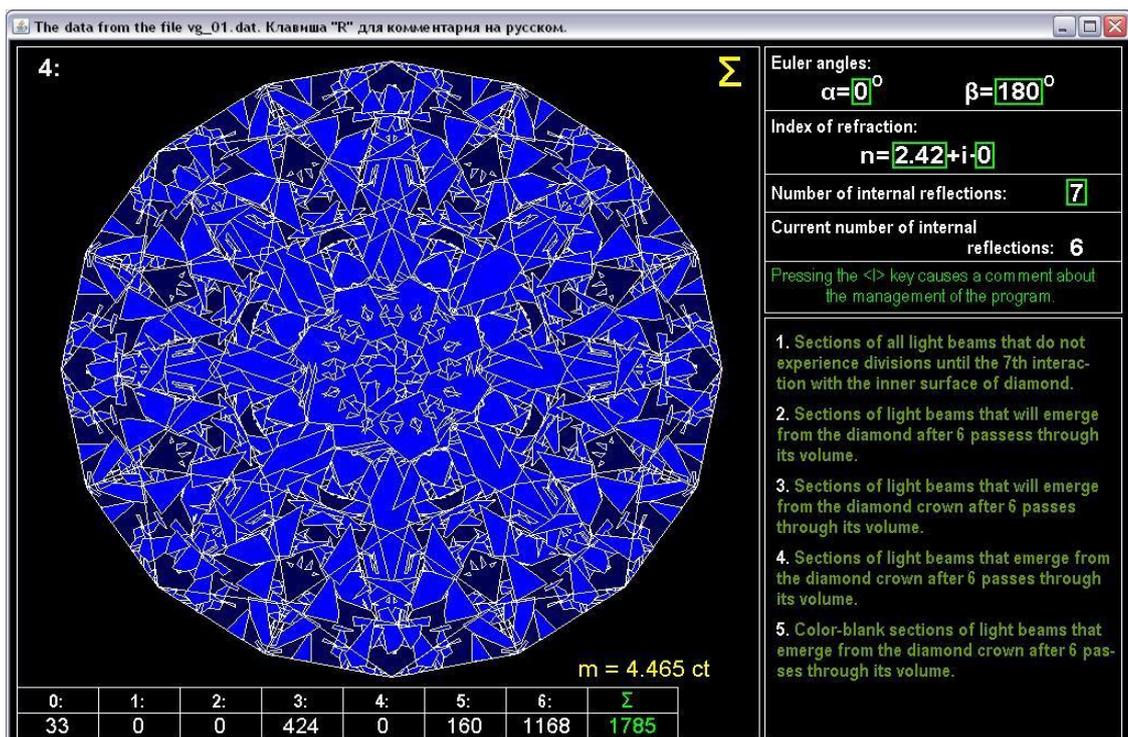


Fig.18. Sections of reflected and out of the crown diamond light beams after 6 divisions and 6 interactions with its faces.

The program allows the analysis of the formed sections of the exited beams at each interaction with boundary of the partition separately from the accumulated sum. To do this, press the "O" key. The crossed-out sum sign at the top of the window means that the sections of the out light beams are considered only the current interaction with the boundary of the partition.

The number of such beams in this case is 72. When the “O” key is pressed again, the program enters then summation mode of all out light beams. In this case, another 72 beams will be added to the diagram shown in Figure 18.

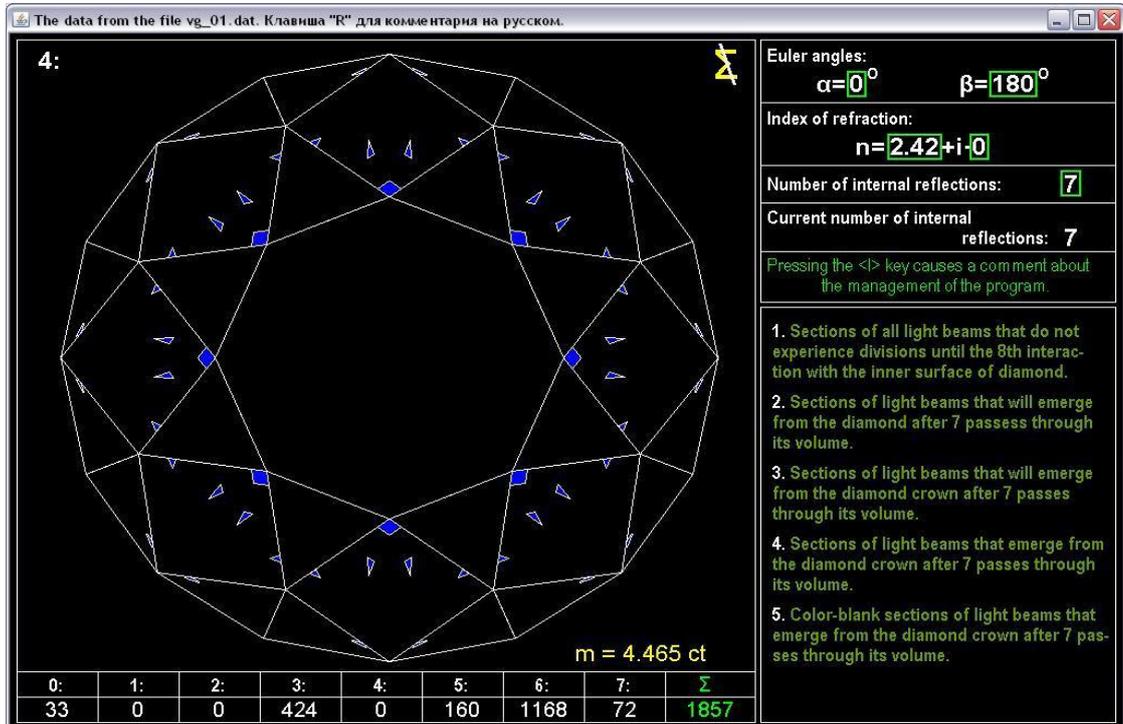


Fig.19. Illustration of the possibility of separating from the total sum of light beams at the current refraction of the faces of the diamond.

Let's introduce a dimensionless characteristic for each j-th light beam:

$$g_j = \frac{k^2}{\pi} \cdot \left( \frac{1 + \cos \vartheta}{2} \right)^2 \cdot |I_j(\vartheta, \varphi)|^2 D_j \cdot e^{-2k\chi R_j} / S \quad (1)$$

Here, the value of  $D_j$  is defined by the following formula:

$$D_j = \frac{|a_{11,j}|^2 + |a_{12,j}|^2 + |a_{21,j}|^2 + |a_{22,j}|^2}{2}$$

In it,  $a_{11,j}$ ,  $a_{12,j}$ ,  $a_{21,j}$ ,  $a_{22,j}$  are expressed through combination of Fresnel coefficients and trigonometric functions of the rotation angles of the components of electromagnetic fields. Such rotation ensures the transformation of the components of the fields so that one of them lies in the plane of incidence of the beam, the other would be perpendicular to it.

The exponential factor is close to 1, but can also differ from it at relatively large values of the imaginary part  $\chi$  of the complex refractive index  $\tilde{n} = n + i\chi$ . The value  $k=2\pi/\lambda$  is a wave number, and  $\lambda$  is a wave length. The light rays that limited the beam inside the volume pass various

paths, so the planes of equal phases and equal amplitudes do not coincide. However, the exponent index in the plane of equal phases varies according to a linear law. As a result,  $R$  is some average value of the path in the crystal for all rays belonging to the  $j$ -th beam.

The function  $I_j(\vartheta, \varphi)$  defines the scattering diagram of the  $j$ -th light beam and is the Fraunhofer integral of the phase function its section.

$$I_j(\vartheta, \varphi) = \iint_{S_j} e^{-ik \sin \vartheta \cos \varphi \cdot x - ik \sin \vartheta \sin \varphi \cdot y} dx dy \quad (2)$$

For the light beam sections shown in Figures 15, 18 and 19, it is necessary to find projections on planes perpendicular to their propagation directions. The  $S_j$  value is such a projection.

In expression (2)  $\vartheta$  and  $\varphi$  are angles of local spherical coordinate system associated with direction of propagation of  $j$ -th beam. The angle  $\vartheta$  is measured from the direction of propagation of the light beam, and  $\varphi$  is an azimuth angle. The coordinates  $x$  and  $y$  are related to the section of the beam through which integration is carried out.

Integral (2) on a polygonal section can be found in analytical form. However, in this case, for comparative analysis of various versions of the circular shape of the diamond, it is of interest to study the sum of peak intensities of all light beams emerging from its crown.

Enter  $g_j|_{\vartheta=0} = G_j$ . Then the peak intensity of the  $j$ -th light beam is determined by the following formula:

$$G_j = \frac{k^2}{\pi \cdot S} \cdot S_j^2 \cdot D_j \cdot e^{-2k\chi R_j} \quad (3)$$

Here and in formula (1), the value  $S$  determines the area of the geometric shadow. If the light beam propagates in the reverse direction, then formula (3) automatically goes into the factor of the backscattering efficiency. In all other cases, it is simply a dimensionless value convenient for analysis.

The data from the file vg\_01.dat. Клавиша "R" для комментария на русском.

Table: Distribution of normalized peak intensities in the corners and place of exit of light beams from the diamond crown.

$(x_0, y_0)$	$\theta^\circ$	[0, 10)	[10, 20)	[20, 30)	[30, 40)	[40, 50)	[50, 60)	[60, 70)	[70, 80)	[80, 90)	$\geq 90$	$\sum$
$<0.05R_3$		5.221 <sub>107</sub> {1}										5.221 <sub>107</sub> {1}
[0.05, 0.15) $R_3$												
[0.15, 0.25) $R_3$												
[0.25, 0.35) $R_3$												
[0.35, 0.45) $R_3$												
[0.45, 0.55) $R_3$												
[0.55, 0.65) $R_3$							3.130 <sub>106</sub> {8}					3.130 <sub>106</sub> {8}
[0.65, 0.75) $R_3$												
[0.75, 0.85) $R_3$								1.491 <sub>107</sub> {8}				1.491 <sub>107</sub> {8}
[0.85, 0.95) $R_3$										1.500 <sub>106</sub> {16}		1.500 <sub>106</sub> {16}
$\geq 0.95R_3$												
$\sum$		5.221 <sub>107</sub> {1}					3.130 <sub>106</sub> {8}	1.491 <sub>107</sub> {8}		1.500 <sub>106</sub> {16}		7.175 <sub>107</sub> {33}

The number of the realized internal reflections: RefT=7; Parameter for viewing of all tables: U=0; ( $0 \leq U \leq \text{RefT}$ )

Fig.20. Peak normalized intensities of 33 light beams reflected from the surface of the diamond.

The data from the file vg\_01.dat. Клавиша "R" для комментария на русском.

Table: Distribution of normalized peak intensities in the corners and place of exit of light beams from the diamond crown.

$(x_0, y_0)$	$\theta^\circ$	[0, 10)	[10, 20)	[20, 30)	[30, 40)	[40, 50)	[50, 60)	[60, 70)	[70, 80)	[80, 90)	$\geq 90$	$\sum$	
$<0.05R_3$		5.221 <sub>107</sub> {1}										5.221 <sub>107</sub> {1}	
[0.05, 0.15) $R_3$						3.087 <sub>104</sub> {16}						3.087 <sub>104</sub> {16}	
[0.15, 0.25) $R_3$		5.794 <sub>106</sub> {8}		5.297 <sub>106</sub> {48}		1.059 <sub>106</sub> {32}						1.215 <sub>107</sub> {88}	
[0.25, 0.35) $R_3$			1.440 <sub>106</sub> {48}	1.886 <sub>105</sub> {32}	9.899 <sub>104</sub> {16}	7.910 <sub>103</sub> {32}	1.256 <sub>104</sub> {16}					1.748 <sub>106</sub> {144}	
[0.35, 0.45) $R_3$				2.062 <sub>103</sub> {16}	7.772 <sub>105</sub> {40}	7.855 <sub>102</sub> {16}			2.208 <sub>101</sub> {16}			7.801 <sub>105</sub> {88}	
[0.45, 0.55) $R_3$		7.712 <sub>101</sub> {8}	9.219 <sub>103</sub> {48}	2.045 <sub>104</sub> {32}		8.246 <sub>104</sub> {8}	3.625 <sub>102</sub> {16}	1.999 <sub>102</sub> {24}	3.702 <sub>102</sub> {32}			1.131 <sub>105</sub> {168}	
[0.55, 0.65) $R_3$		5.910 <sub>102</sub> {16}	1.065 <sub>105</sub> {64}	3.103 <sub>103</sub> {24}	1.837 <sub>101</sub> {16}	5.327 <sub>101</sub> {32}	3.130 <sub>106</sub> {8}	6.704 <sub>10-3</sub> {16}	1.708 <sub>103</sub> {16}	4.503 <sub>101</sub> {8}		3.242 <sub>106</sub> {200}	
[0.65, 0.75) $R_3$		7.224 <sub>103</sub> {16}	2.542 <sub>106</sub> {72}	5.017 <sub>104</sub> {48}	2.717 <sub>104</sub> {32}	3.350 <sub>103</sub> {16}					3.281 <sub>10-1</sub> {16}	2.762 {32}	2.630 <sub>106</sub> {232}
[0.75, 0.85) $R_3$		3.503 <sub>101</sub> {32}	2.256 <sub>101</sub> {32}	2.415 <sub>104</sub> {16}	4.001 <sub>101</sub> {48}	1.919 <sub>104</sub> {64}	5.136 <sub>103</sub> {16}	1.494 <sub>107</sub> {72}			3.249 {16}	1.499 <sub>107</sub> {296}	
[0.85, 0.95) $R_3$		5.172 <sub>104</sub> {32}	3.171 <sub>104</sub> {96}	6.191 <sub>104</sub> {128}	1.275 <sub>103</sub> {16}	2.003 <sub>102</sub> {32}	8.997 <sub>102</sub> {16}	1.673 <sub>10-1</sub> {16}	1.181 <sub>102</sub> {16}	1.502 <sub>106</sub> {32}		1.650 <sub>106</sub> {384}	
$\geq 0.95R_3$		4.087 <sub>10-1</sub> {32}	2.075 <sub>103</sub> {32}	4.043 <sub>102</sub> {32}	6.863 <sub>101</sub> {48}	1.696 <sub>10-2</sub> {16}	1.297 <sub>10-1</sub> {32}	1.256 <sub>10-1</sub> {16}			3.600 <sub>102</sub> {32}	2.909 <sub>103</sub> {240}	
$\sum$		5.806 <sub>107</sub> {145}	4.131 <sub>106</sub> {392}	5.648 <sub>106</sub> {376}	9.049 <sub>105</sub> {216}	1.204 <sub>106</sub> {264}	3.149 <sub>106</sub> {104}	1.494 <sub>107</sub> {144}	2.219 <sub>103</sub> {80}	1.502 <sub>106</sub> {56}	3.660 <sub>102</sub> {80}	8.954 <sub>107</sub> {1857}	

The number of the realized internal reflections: RefT=7; Parameter for viewing of all tables: U=7; ( $0 \leq U \leq \text{RefT}$ )

Fig.21. Peak normalized intensities of light beams reflected and exited the diamond crown.

Now it remains to average function  $k^2 \cdot e^{-2k\chi R_j}$  on the segment  $[k_1, k_2]$  for the visible part of the wavelength range. Value  $k_1$  and  $k_2$  correspond to wavelength  $\lambda_1 = 0.77 \mu m$  and  $\lambda_2 = 0.39 \mu m$ .

After pressing the "F1" key, a table with normalized peak intensities is displayed in program window. The table in Figure 20 can be accessed as soon as the program is loaded. Only light beams reflected from the diamond crown are processed in it. In Figure 21, data for light beams

emerging from the diamond has been to the previously available intensities. After pressing “O” key, the sum of intensities highlight those obtained during the current interaction of light beams with the inner surface of the diamond. Pressing the “O” key again displays the sum of the intensities in the table. The program allows viewing intermediate tables by the “Left” and “Right” keys.

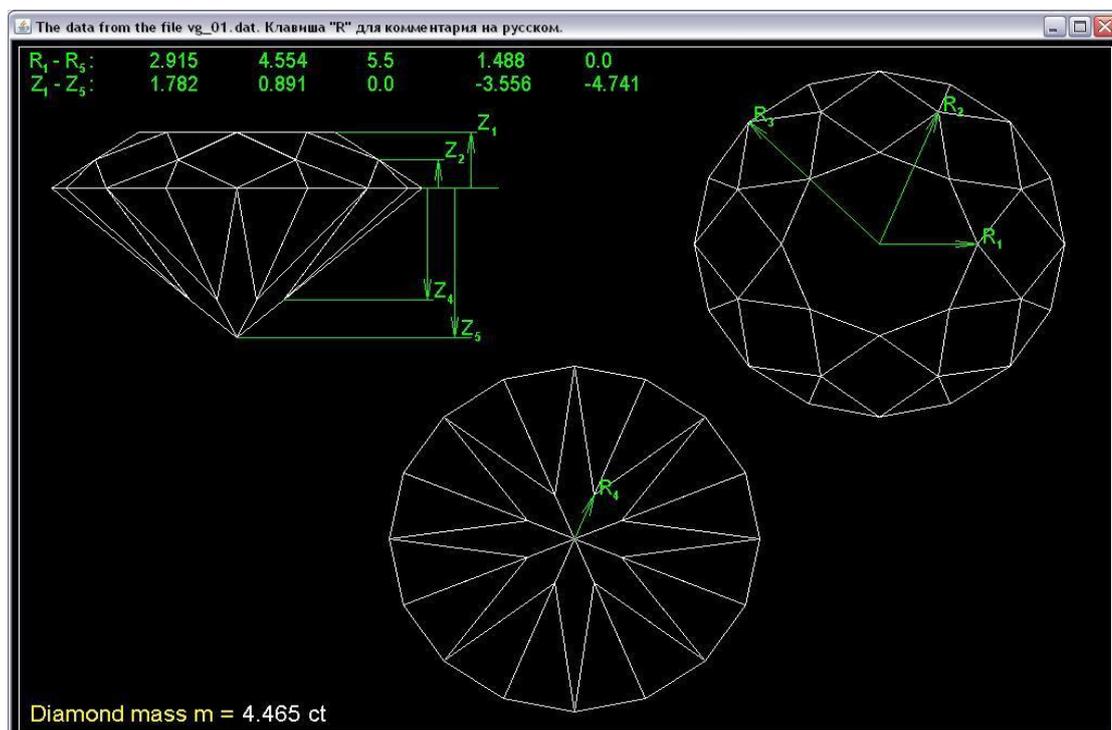


Fig.22. An ideal diamond shape.

The contents of the window shown in Figure 11 can be accessed by pressing the “Home” key. Here are the main dimensions of the diamond of ideal shape. Press the “Page Down” key to move to another round diamond version shown in Figure 23. In this case, the information is read from another file. To return to the previous file, press the “Page Up” key.

For an ideal shape the base dimension  $R_3$  is associated in certain proportions with the dimensions  $R_1$ ,  $Z_1$  and  $Z_5$  [1]. This shape provides 2 complete internal reflections (Figure 15), in which all optical energy is collected inside the diamond. In a third interaction with the inner surface of the diamond, light beams emerge from its crown. It is believed that this form provides the best play of light.

For the reduced pavilion shape variant, light beams also emerge from the diamond crown after 2 complete internal reflections, but not from its central part (Figure 24).

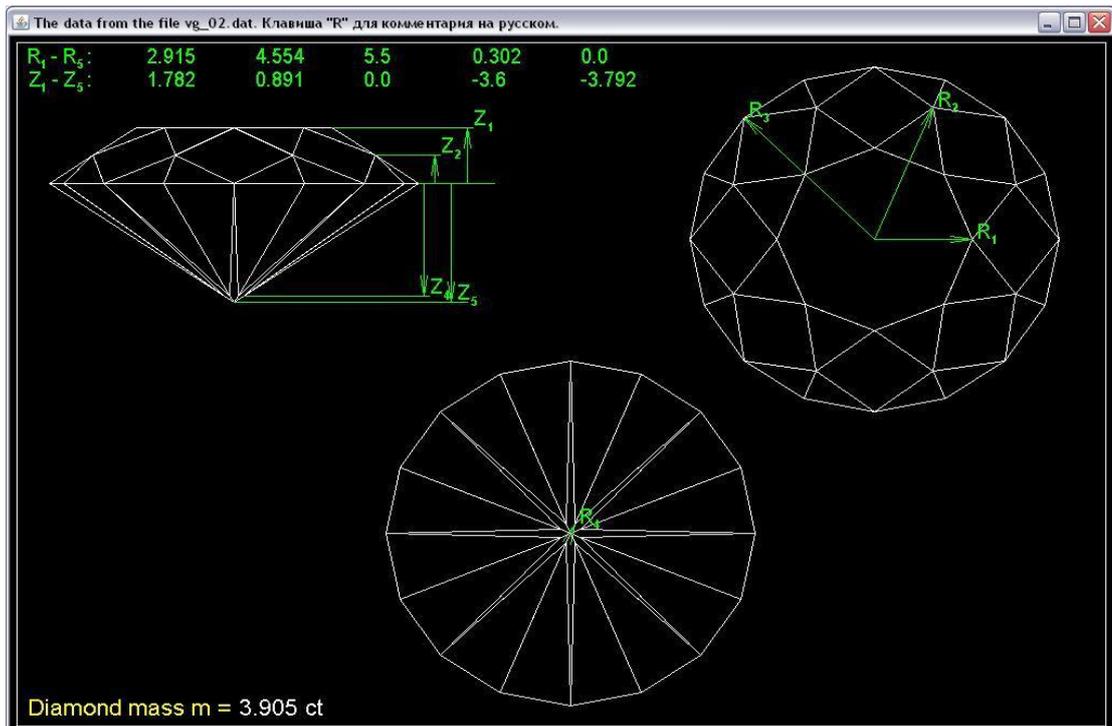


Fig.23. A version of the diamond shape with a reduced pavilion.

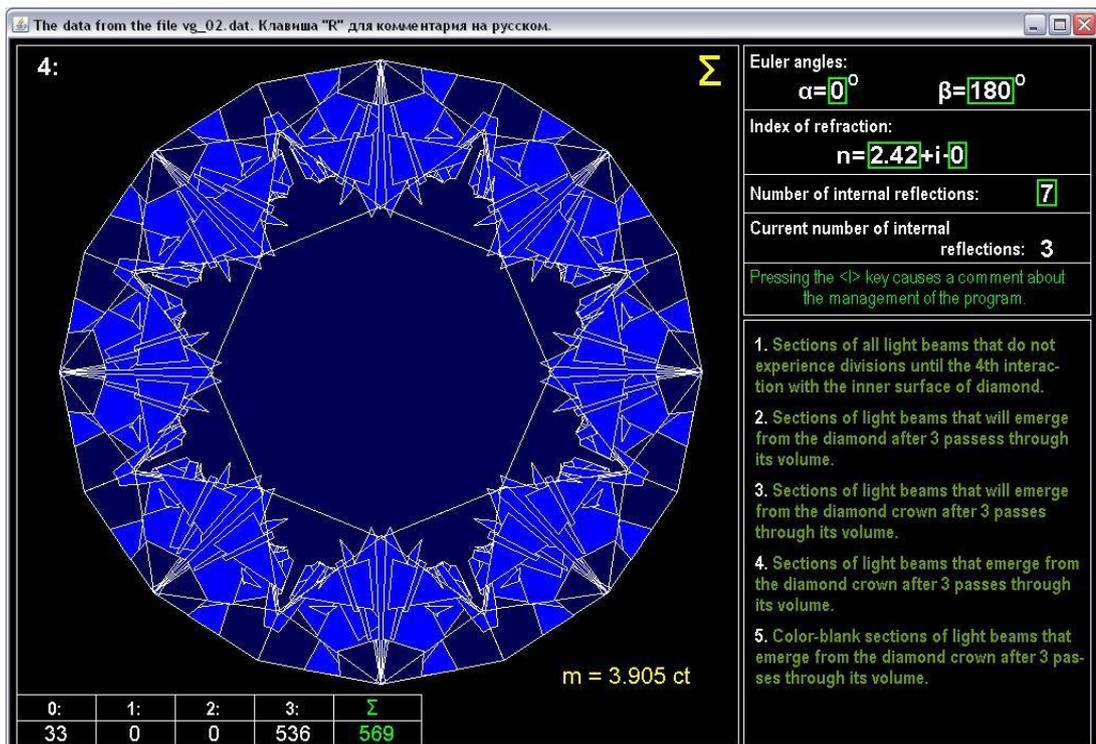


Fig.24. Changing the localization of the out light beams in comparison with the ideal shape of the diamond.

The central part of the crown is filled with sections of light beams not immediately, but after 5 and 6 of their interactions with the inner surface of the diamond (Figure 25).

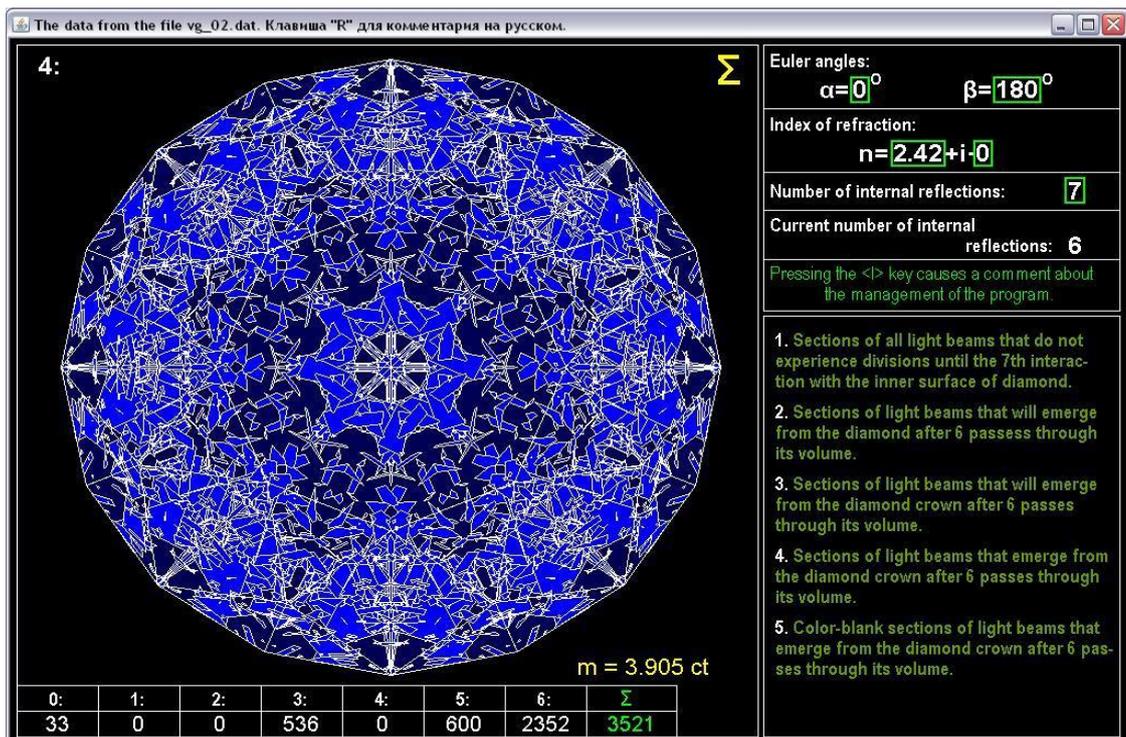


Fig.25. An increase in the number of out light beams in comparison with the ideal shape of the diamond.

The proposed set of programs provides an opportunity to conduct a comparative study of various available options for the round shape of the diamond, as well as find new options.

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