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Quiet@Remove["Global`*"];
SetDirectory[NotebookDirectory[]];
$HistoryLength = 3;

aKrychle = 0.1;
cm = 0.01;
mm = 0.1 cm;

dataElipsoidLS[elipsoid : {stred : {xs_, ys_, zs_}, {a_, b_, c_}, {α_, β_, γ_}}] :=
Module[{m1, m2, m3, xx, yy, zz, parametrizace, vect,
aa, bb, cc, dd, ee, ff, rce, rceVys, line, rhs, mat},
m1 =  $\begin{pmatrix} 1. & 0. & 0. \\ 0. & \text{Cos}[\alpha] & \text{Sin}[\alpha] \\ 0. & -\text{Sin}[\alpha] & \text{Cos}[\alpha] \end{pmatrix}$ ;
m2 =  $\begin{pmatrix} \text{Cos}[\beta] & 0. & -\text{Sin}[\beta] \\ 0. & 1. & 0. \\ \text{Sin}[\beta] & 0 & \text{Cos}[\beta] \end{pmatrix}$ ;
m3 =  $\begin{pmatrix} \text{Cos}[\gamma] & \text{Sin}[\gamma] & 0. \\ -\text{Sin}[\gamma] & \text{Cos}[\gamma] & 0. \\ 0. & 0. & 1. \end{pmatrix}$ ;
xx[t_, u_] := a * Cos[t] * Sin[u];
yy[t_, u_] := b * Sin[t] * Sin[u];
zz[t_, u_] := c * Cos[u];
vect[t_, u_] := {xx[t, u], yy[t, u], zz[t, u]};
parametrizace[t_, u_] := m1.m2.m3.vect[t, u];
line[t_, u_] := Module[{x, y, z},
{x, y, z} = parametrizace[t, u];
{x2, y2, z2, x*y, x*z, y*z}
];
mat = line[Random[], Random[]] & /@ Range[6];
rhs = 1. & /@ Range[6];
rceVys = -1 + ({aa, bb, cc, dd, ee, ff} = Quiet@LinearSolve[mat, rhs]).
{x2, y2, z2, x*y, x*z, y*z};
{elipsoid, {rceVys, rceVys /. {x → x - xs, y → y - ys, z → z - zs},
{aa, bb, cc, dd, ee, ff}},  $\frac{4. \text{Pi}}{3} * a * b * c$ }
];
pom = dataElipsoidLS[{{1, 1, 1}, {1, 2, 3}, {1.3, -1.5, -0.69}}];

elipsoidTrial = {{1, 2, 3}, {4, 5, 6}, {0, 0.25 Pi, 0.33 Pi}};

ClearAll[vseOElipsoidu, x, y, psi, a, b, vyr, axx, axy, ax, ay, a00];
vseOElipsoidu[ξz_, elipsoid_, hue_, listIndexuch_] :=
Module[{dataElipsoid, rceVys, rceVysStred, aa, bb, cc, dd, ee,
ff, ObjemElipsoidu, elipsoidInt, rvs, xvect, dx, a0, b0, c0,
rce, sol, proPlot, pla, plb, xs, ys, vyr, p1, p2, p3, p4, p5, p6,
p7, p8, p9, p10, dosAcka, xss, yss, vyrStred, primka, mm = 0.001,
plot, prusecikSPrimkou, delkaPrusecikuch, delkaPrimek},

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dataElipsoid = {elipsoidInt, {rceVys, rceVysStred, {aa, bb, cc, dd, ee, ff}},
  ObjemElipsoidu} = dataElipsoidLS[elipsoid];
{a0, b0, c0} = dataElipsoid[[1, 2]];
rvs = rceVysStred /. z → ξz * aKrychle;
vyr[xx_, yy_] := rvs /. {x → xx, y → yy};
p1 = vyr[0, 0];
p2 = vyr[0, 1] - p1;
p3 = vyr[1, 0] - p1;
p4 = vyr[1, 1] - p1 - p2 - p3;
p5 = vyr[-1, 0] - p1;
p6 = 0.5 * (p3 + p5);
p7 = vyr[0, -1] - p1;
p8 = 0.5 * (p7 + p2);
p9 = 0.5 * (p3 - p5);
p10 = -0.5 * (p7 - p2);
dosAcka = {a00 → p1, axy → p4, axx → p6, ayy → p8, ax → p9, ay → p10};
{xss, yss} =
  {x, y} /. ( {x → -  $\frac{-axy ay + 2 ax ayy}{-axy^2 + 4 axx ayy}$ , y → -  $\frac{ax axy - 2 axx ay}{axy^2 - 4 axx ayy}$  } /. dosAcka );
vyrStred = vyr[xss, yss];
xvect[psi_, t_] := ( Cos[psi]  -Sin[psi] ) . {a * Cos[t], b * Sin[t]} + {xss, yss};
dx[psi_, t_] := Thread[Rule[{x, y}, xvect[psi, t]]];
rce = (0 == (rvs /. dx[psi, Random[]]) & /@Range[3]);
plot = If[vyrStred < 0,
  sol = Quiet@FindRoot[rce, {psi, 0.65 Pi}, {a, 0.5 a0}, {b, 0.5 b0}];
  proPlot = xvect[psi, t] /. sol;
  pla = ParametricPlot[proPlot,
    {t, 0., 2. Pi}, PlotStyle → {Hue[hue], Thickness[0.005]}];

  Show[pla, PlotRange → All], Null];
prusecikSPrimkou[i_] := Module[{diskriminant, t1, t2, akv, bkv, ckv},
  {akv, bkv, ckv} = {axx, ax + axy i mm, a00 + ay i mm + ayy i2 mm2} /. dosAcka;
  diskriminant = bkv2 - 4. * akv * ckv;
  {t1, t2} =
    { (-bkv -  $\sqrt{\text{diskriminant}}$ ) / (2. akv), (-bkv +  $\sqrt{\text{diskriminant}}$ ) / (2. akv) };
  If[diskriminant ≥ 0, Abs[t2 - t1], 0.];
delkaPrusecikuch = Plus@@(prusecikSPrimkou/@listIndexuch);
delkaPrimek = Length[listIndexuch] * aKrychle;
{plot, {delkaPrusecikuch, delkaPrimek},
  ObjemElipsoidu, If[vyrStred < 0, 1. * Pi * Abs[a] * Abs[b] /. sol, 0.]}
];
poma = vseOElipsoidu[13.5, elipsoidTrial, 0.6, Range[100]] // Timing;

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ClearAll[jenDelky, x, y, psi, a, b, vyr, axx, axy, ax, ay, a00];
jenDelky[ξz_, elipsoid_, listIndexuch_] := Module[
  {dataElipsoid, rceVys, rceVysStred, aa, bb, cc, dd, ee, ff, ObjemElipsoidu,
   elipsoidInt, rvs, rce, xs, ys, vyr, p1, p2, p3, p4, p5, p6, p7, p8, p9, p10,
   dosAcka, mm = 0.001, plot, prusecikSPrimkou, delkaPrusecikuch, delkaPrimek},
  dataElipsoid = {elipsoidInt, {rceVys, rceVysStred, {aa, bb, cc, dd, ee, ff}},
   ObjemElipsoidu} = dataElipsoidLS[elipsoid];
  rvs = rceVysStred /. z → ξz * aKrychle;
  vyr[xx_, yy_] := rvs /. {x → xx, y → yy};
  p1 = vyr[0, 0];
  p2 = vyr[0, 1] - p1;
  p3 = vyr[1, 0] - p1;
  p4 = vyr[1, 1] - p1 - p2 - p3;
  p5 = vyr[-1, 0] - p1;
  p6 = 0.5 * (p3 + p5);
  p7 = vyr[0, -1] - p1;
  p8 = 0.5 * (p7 + p2);
  p9 = 0.5 * (p3 - p5);
  p10 = -0.5 * (p7 - p2);
  dosAcka = {a00 → p1, axy → p4, axx → p6, ayy → p8, ax → p9, ay → p10};
  prusecikSPrimkou[i_] := Module[{diskriminant, t1, t2, akv, bkv, ckv},
   {akv, bkv, ckv} = {axx, ax + axy i mm, a00 + ay i mm + ayy i2 mm2} /. dosAcka;
   diskriminant = bkv2 - 4. * akv * ckv;
   {t1, t2} =
    {(-bkv - √diskriminant) / (2. akv), (-bkv + √diskriminant) / (2. akv)};
   If[diskriminant ≥ 0, Abs[t2 - t1], 0.]];
  delkaPrusecikuch = Plus@@ (prusecikSPrimkou /@ listIndexuch);
  delkaPrimek = Length[listIndexuch] * aKrychle;
  {delkaPrusecikuch, delkaPrimek}
];
poma = jenDelky[13.5, elipsoidTrial, Range[100]] // Timing;

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nDeleni = 17;

$$\Delta x = \frac{aKrychle}{nDeleni + 1};$$


SeedRandom[1];

k = 0.3;
rTypicky = 0.2 *  $\Delta x$ ;
rnSouradnice := RandomReal[{-k * rTypicky, k * rTypicky}];
rnPoloosa := RandomReal[{0, k * rTypicky}];

rnabc := 10 * rnPoloosa & /@ Range[3];
rnUhel := RandomReal[{-0.5 Pi, 0.5 Pi}];
rna $\beta$  $\gamma$  := rnUhel & /@ Range[3];
stredy =
  Flatten[Table[{x + rnSouradnice, y + rnSouradnice, z + rnSouradnice}, {x,  $\Delta x$ ,
    aKrychle -  $\Delta x$ ,  $\Delta x$ }, {y,  $\Delta x$ , aKrychle -  $\Delta x$ ,  $\Delta x$ }, {z,  $\Delta x$ , aKrychle -  $\Delta x$ ,  $\Delta x$ }], 2];

(*prusecik elipsoidu s rovinou z=konst. a primkou v ni*)
SeedRandom[3];
nmax = Length[stredy];
elipsoid1[i_] := {stredy[[i]], rnabc, rna $\beta$  $\gamma$ };
elipsoidy = elipsoid1 /@ Range[nmax];
eltry = elipsoidy[[150]];
 $\xi z$ Try = 0.45;

ClearAll[zpracuj];
zpracuj[ $\xi z$ _, listIndexuch_] := Module[{test, podezrele, nElMax, vysledky},
  test[{{xs_, ys_, zs_}, {a_, b_, c_}, { $\alpha$ _,  $\beta$ _,  $\gamma$ _}}] :=
    Abs[zs - aKrychle *  $\xi z$ ] < 0.5 *  $\Delta x$ ;
  podezrele = Union[Select[elipsoidy, test]];
  nElMax = Length[podezrele];
  Print["podezrelych elipsoidu geft: ", nElMax];
  vysledky = vseOElipsoidu[ $\xi z$ , #, Random[], listIndexuch] & /@ podezrele
];
 $\xi z$ Try = 0.59;
pom = zpracuj[ $\xi z$ Try, Range[100]] // Timing;
Print["trvalo to ", pom[[1]], " s"]

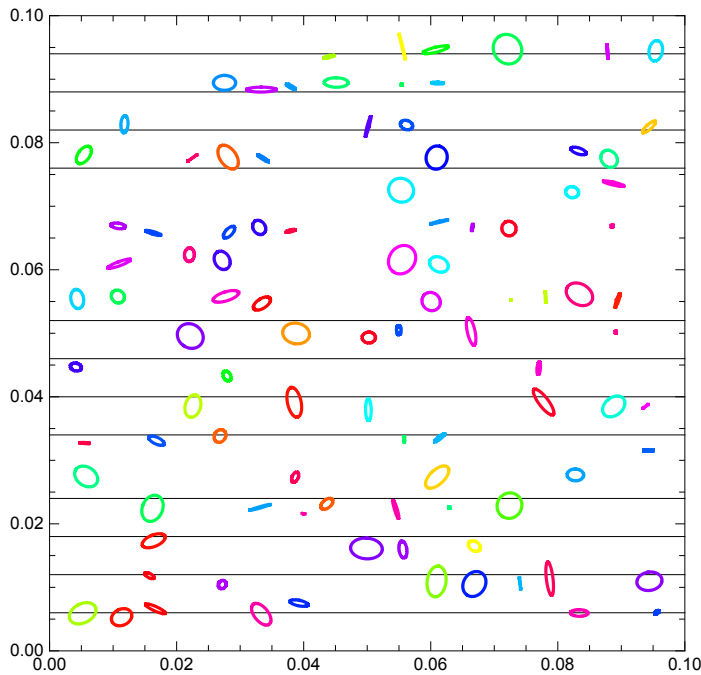
podezrelych elipsoidu geft: 289
trvalo to 4.016 s

vysledky = pom[[2]];
rezy = Quiet@Show[DeleteCases[First /@ vysledky, Null],
  PlotRange  $\rightarrow$  {{0, aKrychle}, {0, aKrychle}}, Axes  $\rightarrow$  False, Frame  $\rightarrow$  Automatic];

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(*Export["vysgraf.png", rezy, ImageResolution->300]*)

listIndexuch1 = Range[1, 99, 1];
listIndexuch2 = {6, 12, 18, 24, 34, 40, 46, 52, 76, 82, 88, 94};
primka[i_] := Graphics[Line[{{0, i * mm}, {aKrychle, i * mm}}]];
plPrimky = Show[primka /@ listIndexuch2,
  PlotRange -> {{0, aKrychle}, {0, aKrychle}}, Axes -> False, Frame -> Automatic];
dohr = Show[plPrimky, rezy]
(*Export["vysgrafS.png", dohr, ImageResolution->300]*)
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celkovyObjemPoru =  $\frac{4}{3} * \text{Pi} * \text{Plus}@@(\text{elipsoidy} /. \{\{xs_, ys_, zs_}, \{a_, b_, c_}, \{\alpha_, \beta_, \gamma_}\} \Rightarrow a * b * c);$ 

provitostSkutecna = 100  $\frac{\text{celkovyObjemPoru}}{\text{aKrychle}^3};$ 
Print["porovitost skutecna= ", provitostSkutecna, " %"]
porovitost skutecna= 9.71739 %
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ClearAll[zpracujJenDelky];
zpracujJenDelky[ξz_, listIndexuch_] :=
Module[{test, podezrele, nElMax, vysledky},
test[{{xs_, ys_, zs_}, {a_, b_, c_}, {α_, β_, γ_}}] :=
Abs[zs - aKrychle * ξz] < 0.5 * Δx;
podezrele = Union[Select[elipsoidy, test]];
nElMax = Length[podezrele];
(*Print["podezrelych elipsoidu geft: ", nElMax];*)
vysledky = jenDelky[ξz, #, listIndexuch] & /@ podezrele
];
pom = zpracujJenDelky[ξzTry, Range[100]] // Timing;

ClearAll[zpVysledky];
zpVysledky[listDvojic_] := Module[{delkyPresPory, delkyCelkem},
delkyPresPory = Plus@@(First/@listDvojic);
delkyCelkem = listDvojic[[1, 2]];
{delkyPresPory, delkyCelkem};
100 *  $\frac{\text{delkyPresPory}}{\text{delkyCelkem}}$ 
];

ClearAll[vydejProKsiz];
vydejProKsiz[ξz_, listIndexuch_] := Module[{zpracvysledky, vysDelky1},
vysDelky1 = zpracujJenDelky[ξz, listIndexuch];
zpVysledky[vysDelky1]
];
v1 = vydejProKsiz[ξzTry, listIndexuch1];
v2 = vydejProKsiz[ξzTry, listIndexuch2];
Print["spravne= ", provitostSkutecna,
", po milimetru= ", v1, " podle normy= ", v2, " %"]

spravne= 9.71739, po milimetru= 3.91675 podle normy= 4.44777 %

dats = Quiet@vydejProKsiz[#, listIndexuch1] & /@
Range[0.5 Δx, aKrychle - 0.5 Δx,  $\frac{\text{aKrychle} - \Delta x}{1.2345 * \text{nDeleni}}$ ];

prumerna = Mean[nr = DeleteCases[np = dats, 0]];
Print["prumerna= ", prumerna, " % chyba= ", 100  $\frac{\text{provitostSkutecna} - \text{prumerna}}{\text{provitostSkutecna}}$ ,
" %, pri poctu ", Length[nr], " rezu, σ = ", StandardDeviation[nr], " %"]
prumerna= 9.42008 % chyba= 3.05952 %, pri poctu 16 rezu, σ= 7.45367 %

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dats2 = Quiet@vydejProKsiz[#, listIndexuch2] & /@
  Range[0.5 Δx, aKrychle - 0.5 Δx,  $\frac{aKrychle - \Delta x}{1.2345 * nDeleni}$ ];

prumerna2 = Mean[nr2 = DeleteCases[np2 = dats2, 0]];
Print["prumerna= ", prumerna2, " % chyba= ", 100  $\frac{provitostSkutecna - prumerna2}{provitostSkutecna}$ ,
  " %, pri poctu ", Length[nr2], " rezu, σ= ", StandardDeviation[nr2], " %"]
prumerna= 11.6965 % chyba= -20.367 %, pri poctu 16 rezu, σ= 8.9775 %

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