E2

STABILITY OF MULTIPASS CELLS WITH DIFFERENT OPTICAL SCHEMES

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Introduction

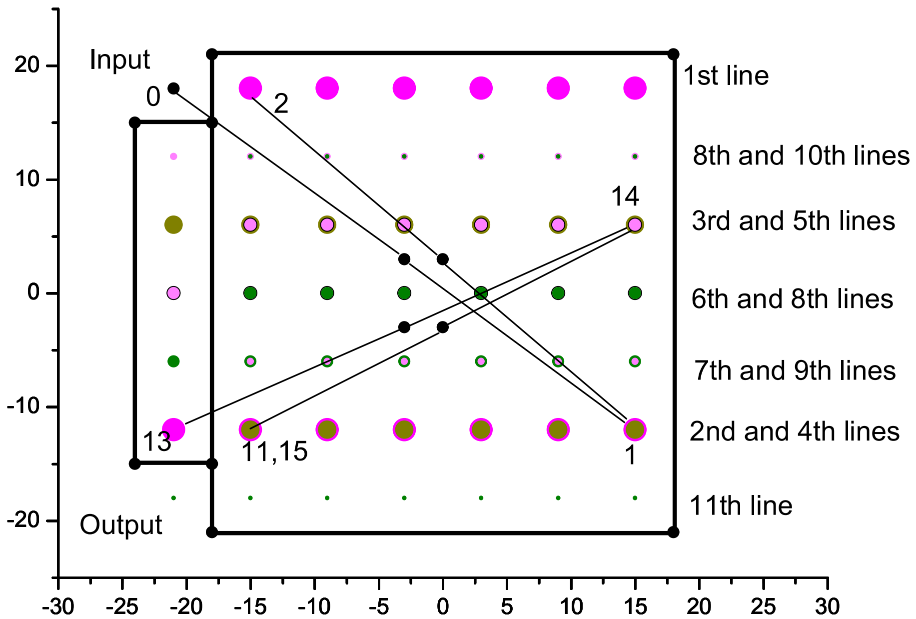
A comparison of four multipass optical schemes was conducted: the Herriott type [1], astigmatic Herriott type [2], modified Herriott type with cut and tilted mirror [3], and matrix four-objective Chernin cell [4]. For comparison, the external sizes of all systems were chosen the same.

The positions of spots of the propagating beam on mirrors for a given optical scheme were calculated, and the variation of these positions due the change of describing system parameters, were calculated. These variations, normalized to initial parameter change, were called instability coefficients and were calculated for each pass number. The angle parameters were substituted by coordinate ones by multiplying angles on corresponding mirror or input element sizes.

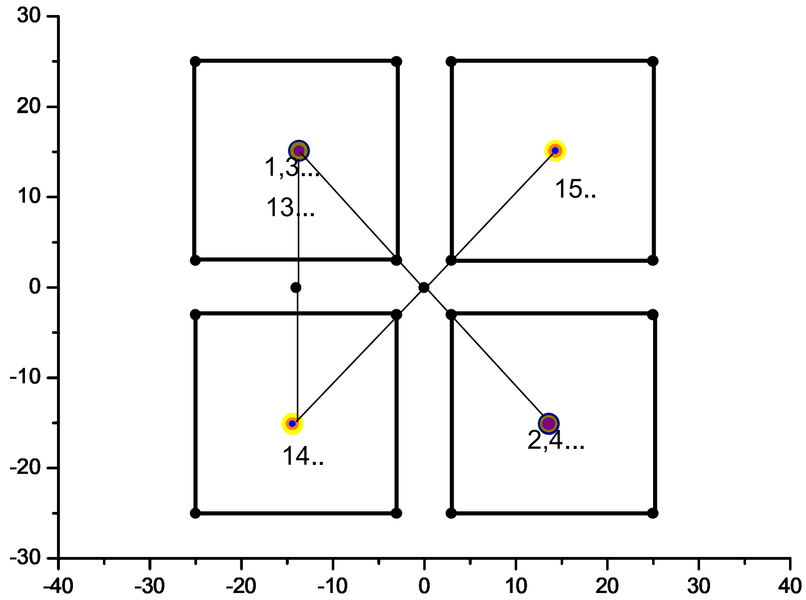
Varying parameters: input beam parameters (two coordinates and two angles) and the positions of mirrors (three coordinates and three angles for each mirror). Radii of curvature (two radii in the case of astigmatic mirrors) were considered as constant.

[1] D.R.Herriott, H.Kogelnik, and R.Kompfer, Appl.Opt.3, 523 (1964).
[2] D.R.Herriott and H.J.Shulte, Appl.Opt. 4, 883 (1965).
[3]C. Robert, Appl.Opt. 46, 22, 5408, (2007).
[4]S.M.Chernin, J.Mod.Opt., 48, 619 (2001).

Chernin four objective multipass cell

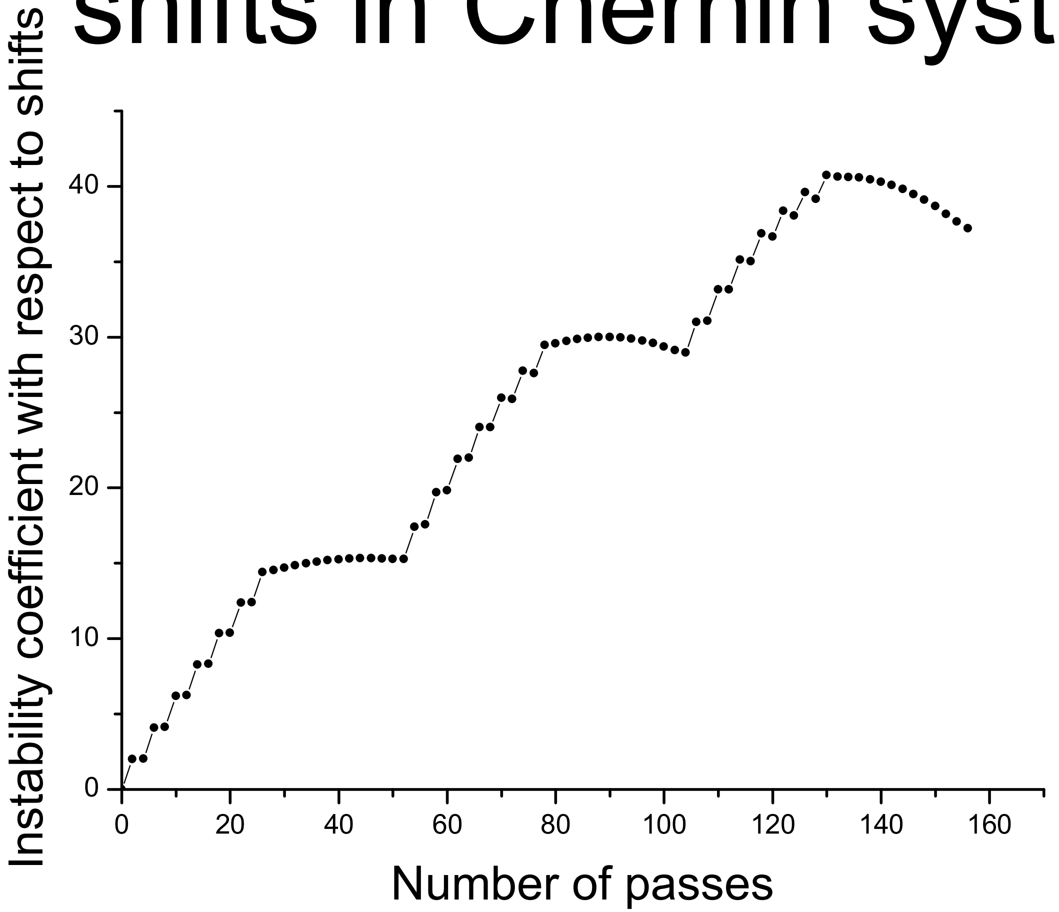


Arrangements of spots and objective centers position on field mirrors



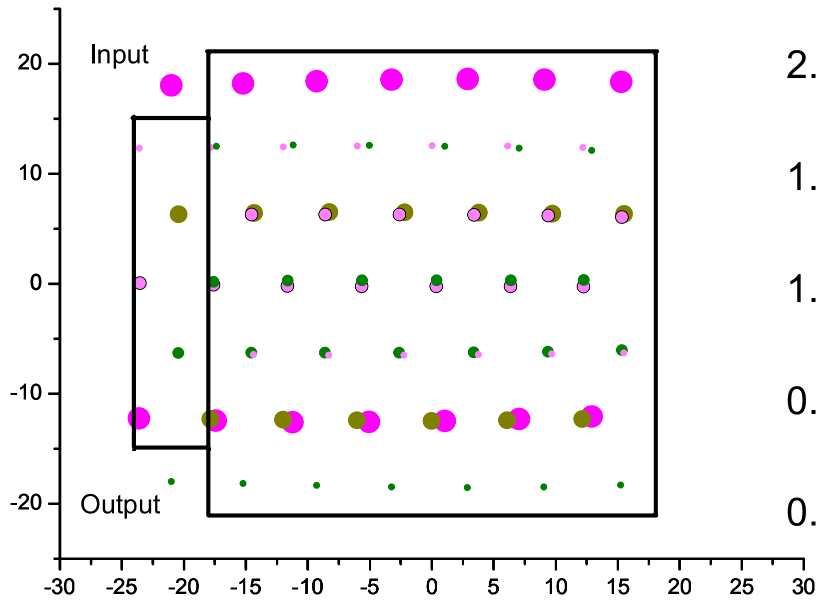
Arrangement of spots on objectives and position of field mirrors centers

Instability coefficients for objective shifts in Chernin system

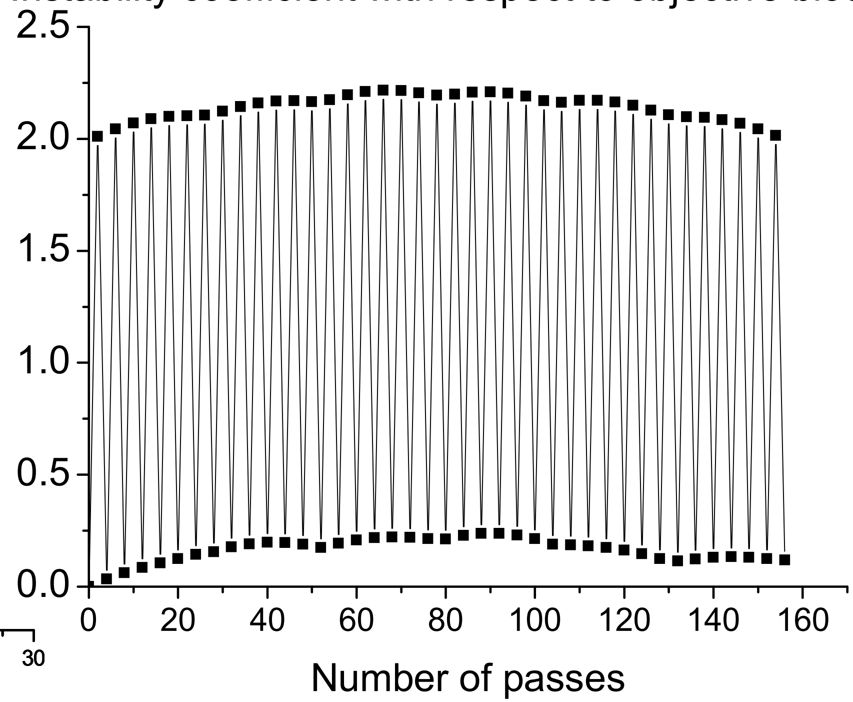


Instability coefficient with respect to shift of one of the objectives – system is highly sensitive. Instability coefficient with respect to objectives inclinations are 10 times higher

Shifts and inclinations of objective block in Chernin system



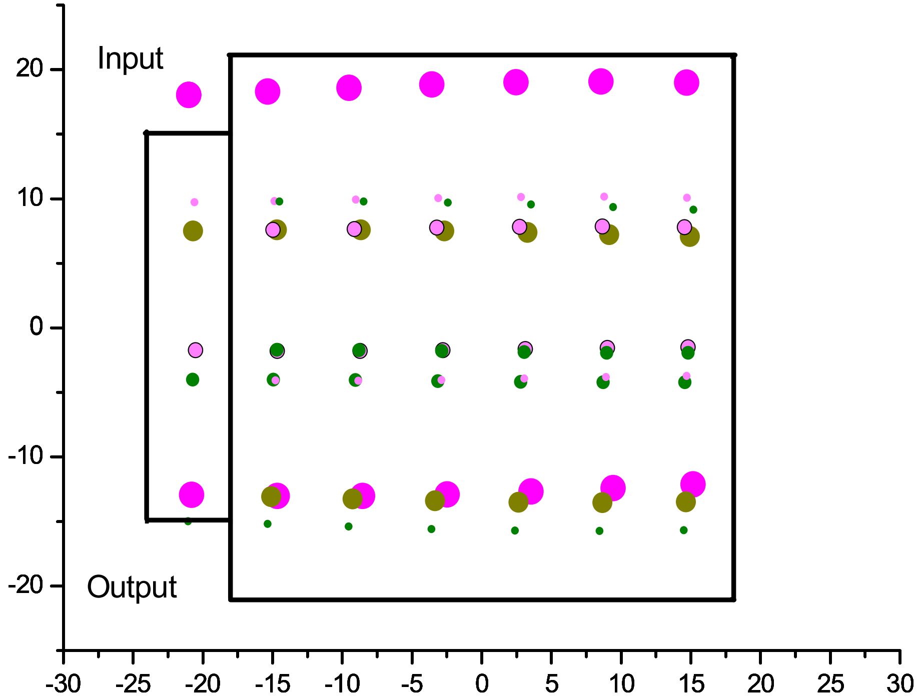
Change of picture of the field mirrors at shift of the objectives block on X axis by -1.4 mm

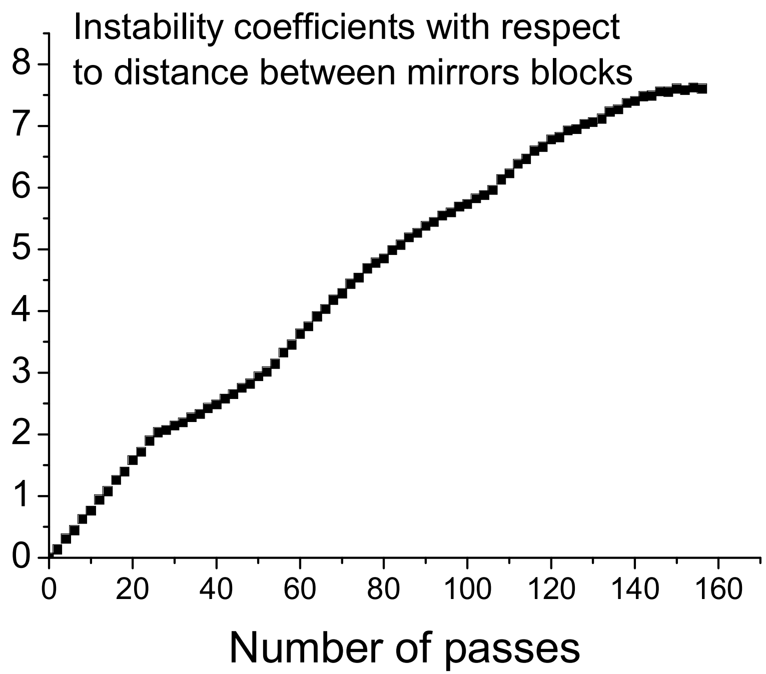


Instability coefficients with respect to objectives block shift along X axis as a function of number of passes for Chernin system

Inclinations would lead to the same effects, but the system is approximately 5 times more sensitive

Instability coefficients with respect to distance between mirrors blocks in Chernin system

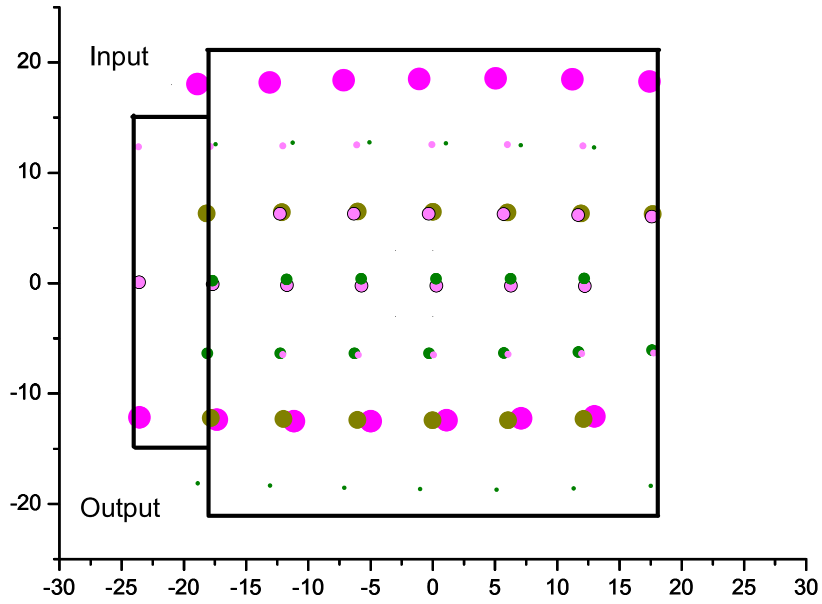




Arrangement of spots on the field mirrors at the objectives block moving off by 0.38 mm

Instability coefficients with respect to distance between mirrors blocks on number of passes for Chernin system

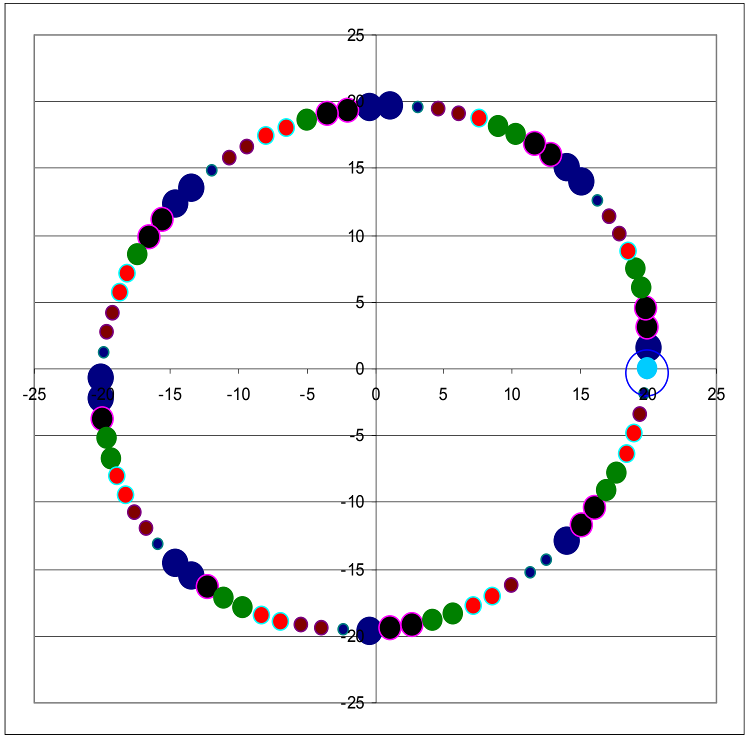
Input stability, Chernin system

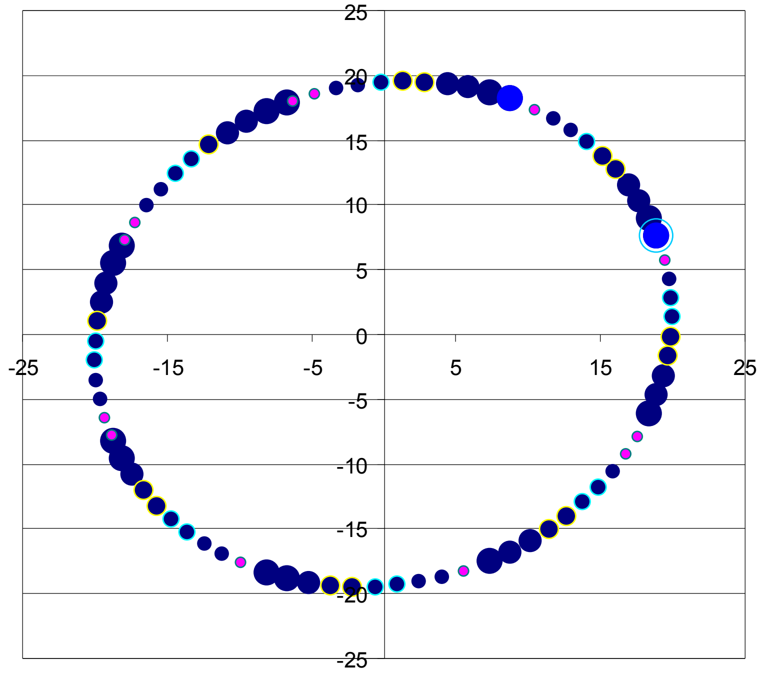


Arrangement of spots on field mirrors at shift of input source by 2.1 mm along X axis

Chernin system is stable with respect to input shifts and highly stable to input beam direction (within a certain range)

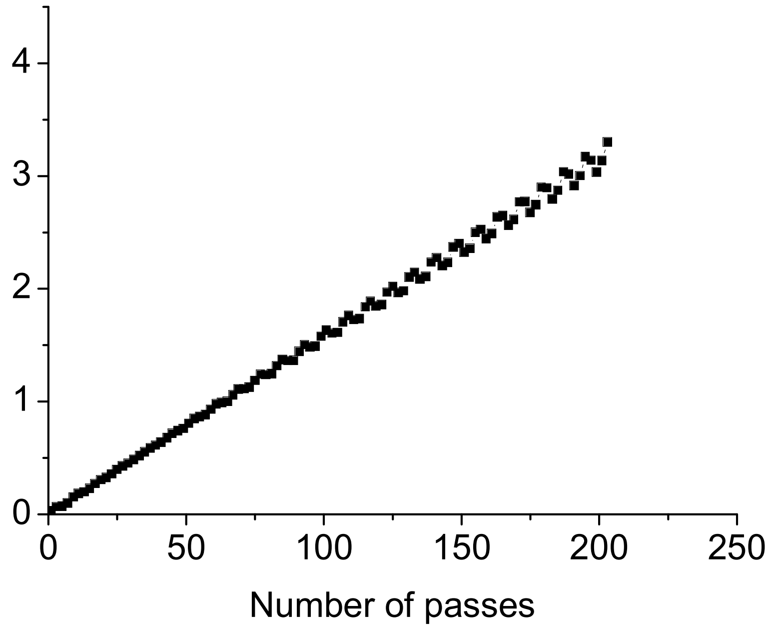
Herriott system



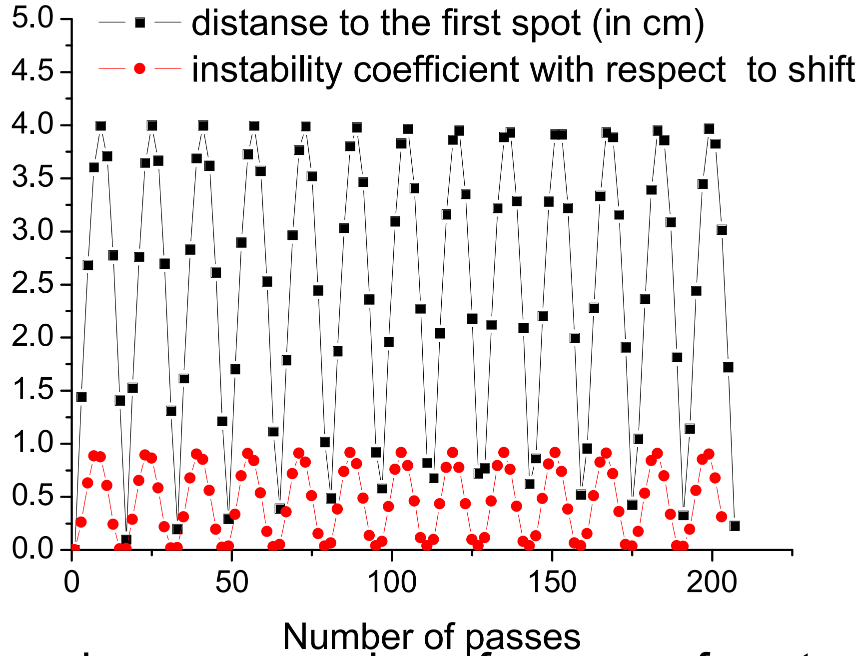


Arrangement of spots in Herriott system with nearly circle form. Left – input (first) mirror, input beam is shown by large open circle, small blue spot – output beam; right graph – second mirror

Herriott system, instability

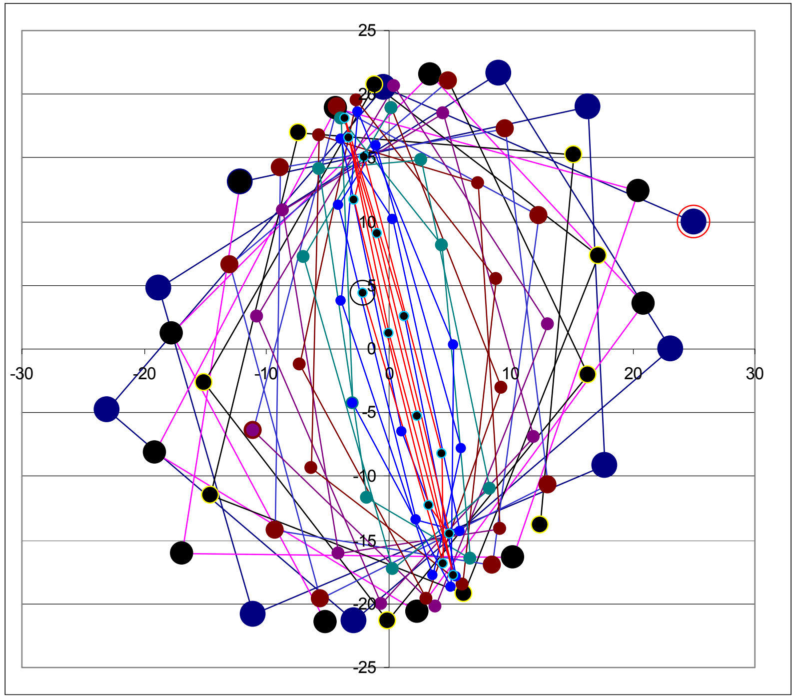


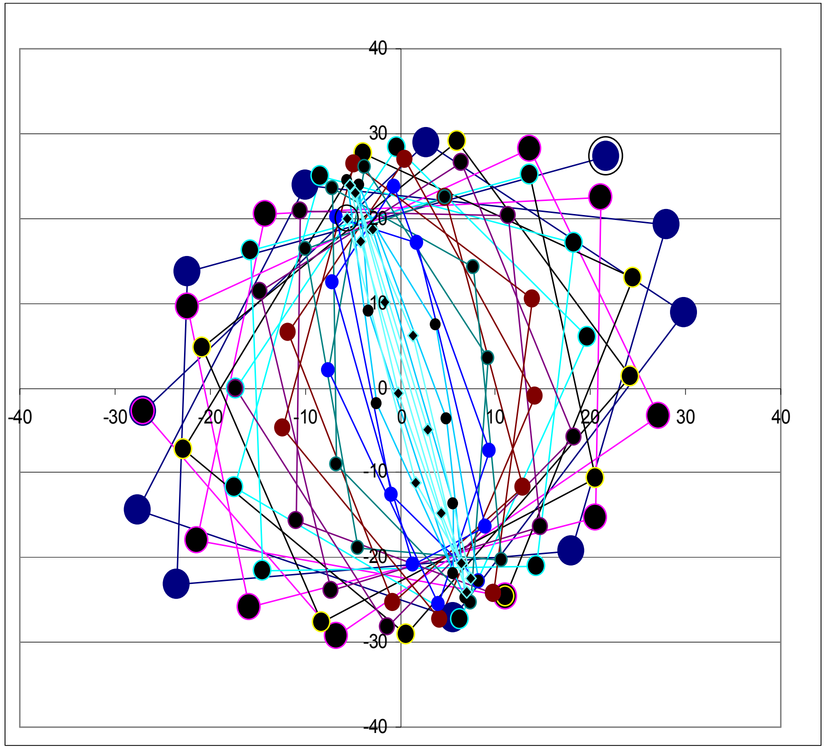
Dependence of distance instability coefficients as a function of number of passes for the case of circular arrangement of spots



Dependence on number of passes of spots actual shift (red squares, in mm) on first mirror and distance from first spot to current (black rhombs, in cm) as a function of number of passes at shift of first mirror with respect to second by 1 mm along X axis

Astigmatic Herriott system

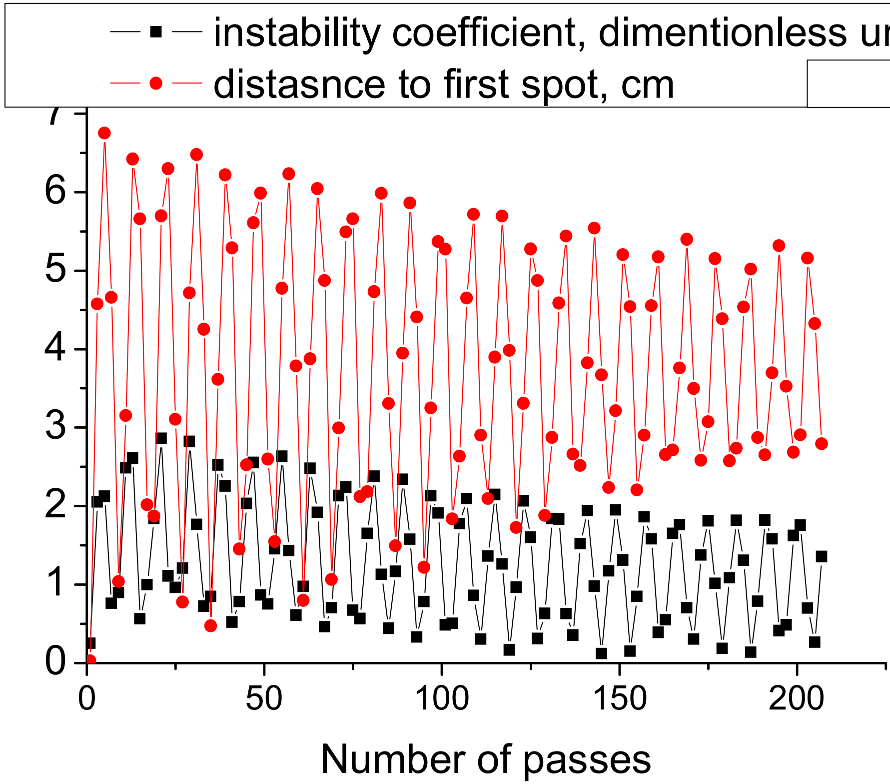




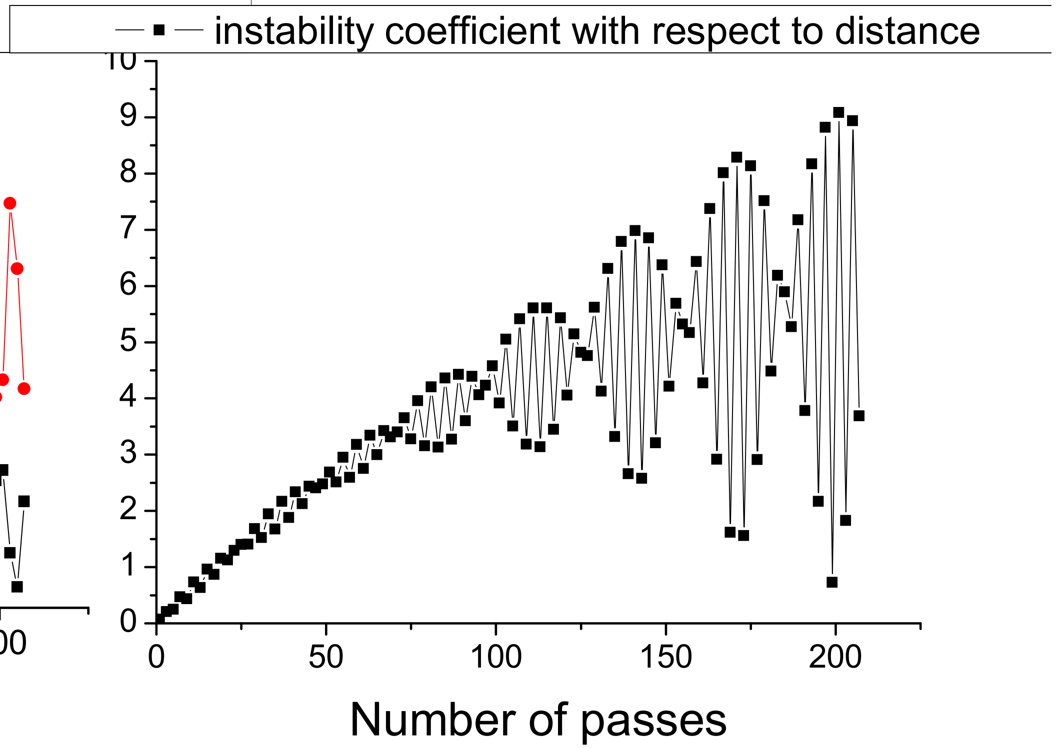
Arrangement of spots on first (left graph) and second (right) mirror in astigmatic Herriott system with parameters given below

		first mirror	second mirror
R,radius		**550**	**100000**
D, distance between mirrors		**244**	**244**
cylindrical astigmatism R1		**8000.00**	

Astigmatic Herriott system, instability

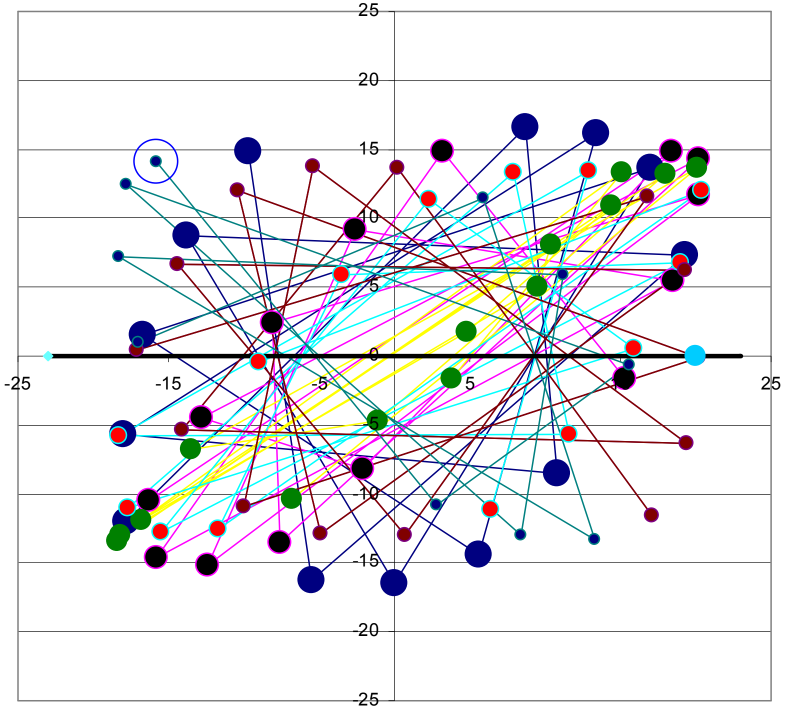


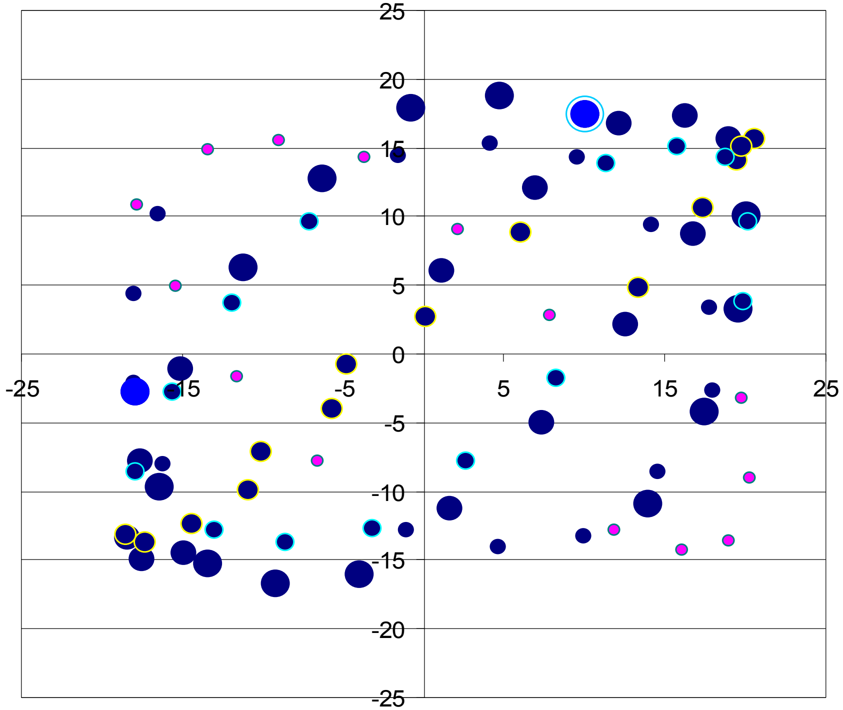
Typical dependence of instability coefficient with respect to inclination and distance to first spot in astigmatic Herriott system



Typical dependence of instability coefficient with respect to distance between mirrors for astigmatic Herriott system

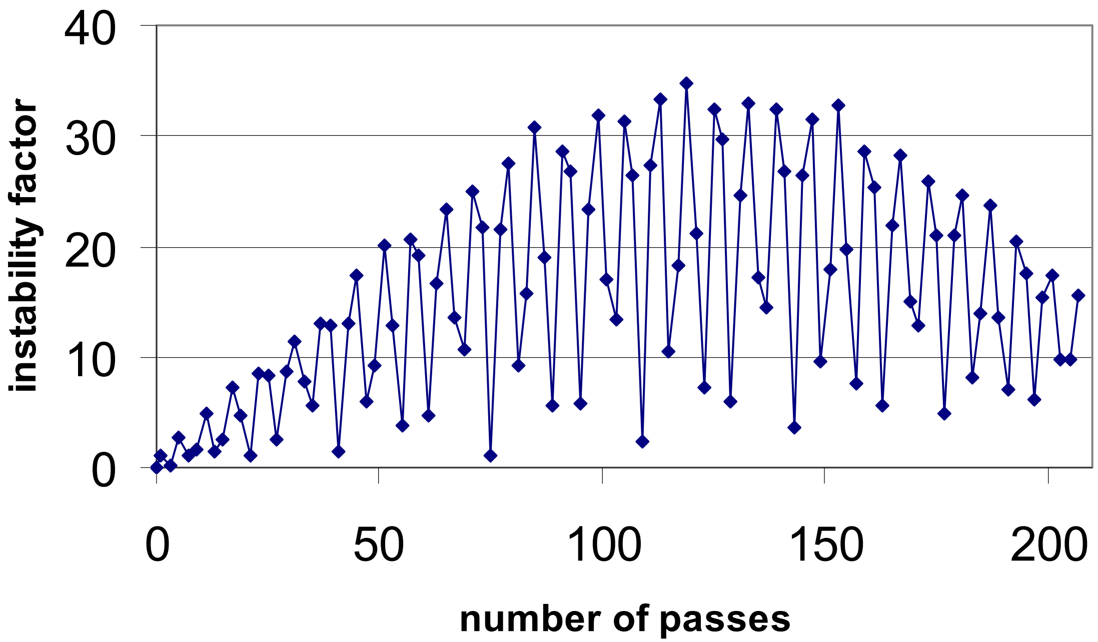
Herriott system with cut mirror





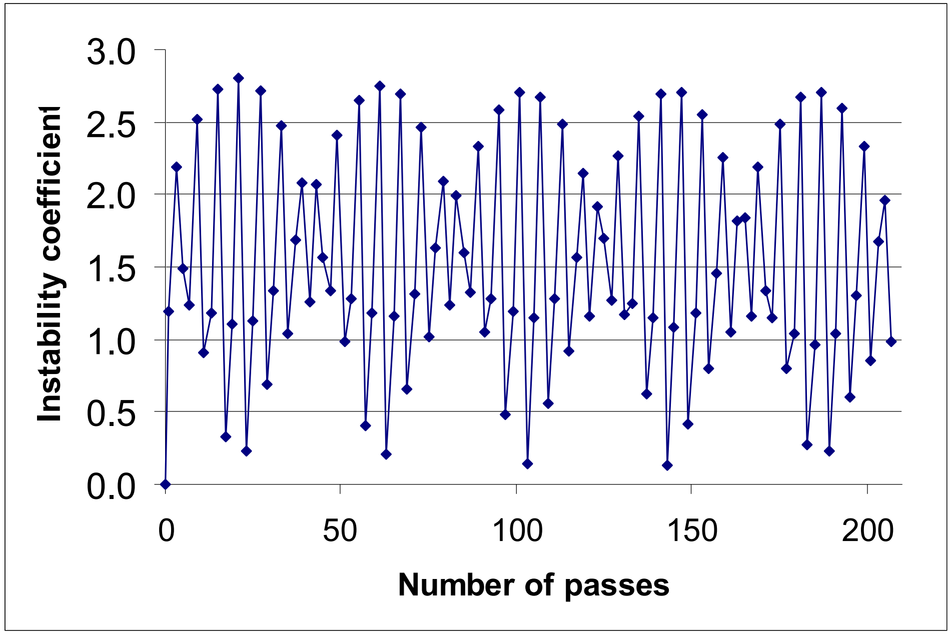
input x0	20		Coordinates of mirror centers	X	Y
input y0	0		First mirror 1	0.00	-1.01
	first mirror1,2	second mirror	First mirror 2	0.00	1.01
R,radius	500	500	Second mirror	0.00	0.00
distance	272				

Herriott system with cut mirror, instability relative to the half-mirror position

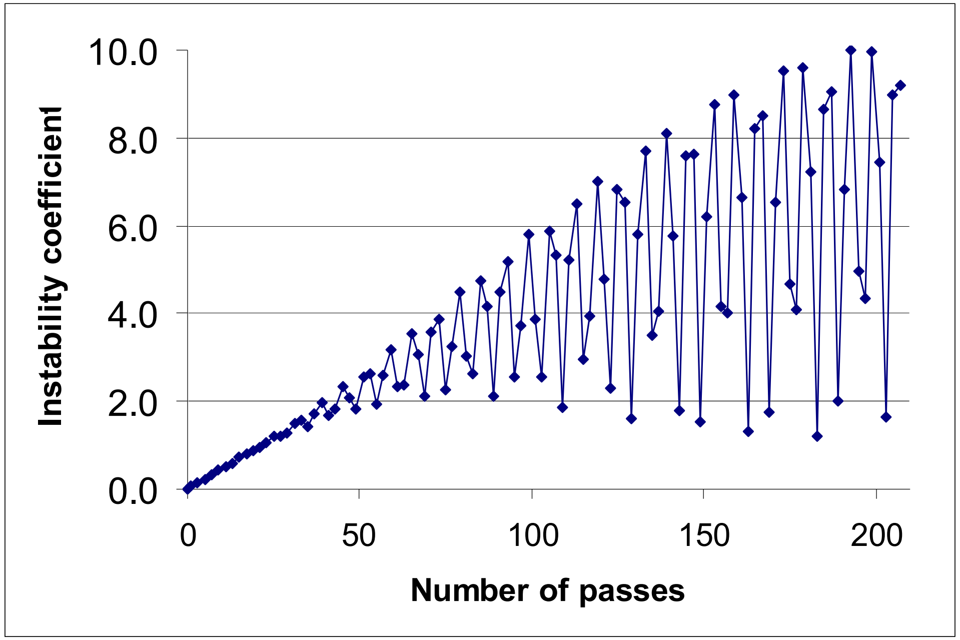


Instability coefficients with respect to variation of distance between two mirror halves

Herriott system with cut mirror, instability relative to the position of second mirror



Instability coefficient with respect to mutual shift of two mirror halves 1 mm along the Y axis



Instability coefficient with respect to change in distance between mirrors

Instability coefficients for different systems

	Chernin system	Herriott system	Astigmatic Herriott system	Herriott with cut mirror (Robert)
Objective's (or half of the mirror's) shifts	32 - 37	-	-	25 - 30
Objective's (or half of the mirror's) declinations	350 - 420	-	-	20 - 450
Objectives block (first mirror) shifts	0. 09 – 0.15	0.2 -1.8	0.1 - 2	0.2 - 4
Objectives block (first mirror) declinations	0.017 – 0.86	1 - 9	0.5 - 10	1 - 20
Change of distance between two mirrors (two blocks)	7.7	3.2 - 6	1 - 9	1 - 8
Input, coordinates	0.9 – 1.1	0.9 – 1.1	0.8 – 1.2	0.8 – 1.2
Input, angles	0.012- 0.026	10	8 - 12	8 - 12

SUMMARY

The dependences of instability coefficients for Herriott systems in most cases were oscillating, so there was a chance to choose the output beam with high stability. However, the position of output beam in modified Herriott systems was dictated by different requirements: closeness of output beam to neighbor spots and intermediate spots to mirror edges, and more or less uniform distribution of spots over mirror surface. We did not succeeded in finding the geometry of Herriott system in which minimums of instability coefficients for different variables coincide.

The Chernin systems and cut mirror ([3]) system are unstable with respect to mutual position of objectives or mirror halves, but both systems could be made stable with respect to these parameters if objectives or cut mirror are designed as the rigid blocks. All systems are unstable with respect to changing distance between mirror blocks. All Herriott systems are unstable with respect to direction of input beam, while Chernin system is highly stable to this parameter. Chernin system is also easier in alignment due to regular matrix of images on field mirrors.