



Deformable Mirrors

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bertin

DM Catalogue

Our Company

Bertin Alpao, a subsidiary of the Bertin Technologies Group, manufactures adaptive optics components and systems for research and industry. Since its inception in 2007, Bertin Alpao have shown a strong commitment to research and development, revolutionizing the field of adaptive optics by providing highly reliable and precise solutions.

The company designs and produces a wide range of deformable mirrors (DMs), wavefront sensors (WFS), and tailor-made adaptive optics systems, for demanding applications including space, astronomy, optical communications, quantum key distribution, ophthalmoloy, microscopy, microelectronics and laser applications. Bertin Alpao empowers users to correct optical aberrations in real time, enabling ultra-high resolution imaging or very low communication losses.

Our Technology

Bertin Alpao's Deformable Mirrors are powered by state-of-the-art electromagnetic actuators, which offer unparalleled precision, speed, and reliability.

These advanced actuators employ the magnetic force generated by the interaction between a coil and a magnet to accurately control the movement of the mirror surface. Electromagnetic actuators also boast rapid response times, enabling real-time adjustments to account for dynamic changes in the optical environment.





Key Features and Benefits

- Superior best flat
- Excellent linearity
- Low hysteresis
- Vacuum compatibility
- Large variety of options
- Proven electromagnetic technology

- Wide range of accessories
- High dynamic motion
- Very high number of actuators
- Low power consumption
- Large deformation capacities
- SDK available for C++, Python, Matlab

Applications





Smart Deformable Mirror (sDM)

Bertin Alpao's Smart Deformable Mirror (sDM) is a competitive solution allowing to meet non-critical technical performance requirements while ensuring the fundamental functionality of adaptive optics: optical aberration correction. With 37 actuators, the DM combines high stability and large stroke capabilities, making it an ideal choice for budget-conscious users.

Designed for industrial applications, Smart Deformable Mirrors are optimized



for open-loop operation, ensuring reliable performance in demanding environments.

Bertin Alpao's Smart Deformable Mirror is compatible with the Bertin Alpao environement but also with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, Bertin Alpao provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



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sDM Technical Specifications

	DM 37
Number of actuators	37
Actuator matrix size	7x7
Pupil diameter (mm)	7.5
Pitch (mm)	1.5
Number of actuators across a diameter	7
Active best flat (nm RMS, mechanical) _{max}	15
Tip/Tilt stroke (µm PV, wavefront) _{min}	50
Defocus/Astig stroke (µm PV, wavefront) _{min}	30 / 40
3x3 stroke (µm PV, wavefront) _{min}	40
Settling time (ms at -/+ 10%, any stroke) _{max}	1.5
First resonance of the membrane (Hz) _{min}	900
Frequency at phase lag of 45° (Hz) _{min}	800
Mochanical W/ x H x D (mm)*	51 5774755 0

Mechanical W x H x D (mm)*	51.5x74x55.9
Weight (kg)*	245
*Preliminary specifications	
Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminum and Dielectric

Functional temperature (°C)	-50 to 50
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)
Maximum floating actuator count	0
All main technical specifications are valid at a temp	erature of 21 ± 4 °C.



DM Catalogue

Embedded Deformable Mirrors (eDM)

Bertin Alpao's Embedded Deformable Mirror (eDM) is a compact and cableless solution with no external electronics. With less than a 100 actuators, the mirror offers high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision.



Compact Deformable Mirrors are ideal for space constraint applications such as optical ground stations, microscopy and ophthalmology where the device will be placed alongisde small instruments.

Each Deformable Mirror is designed to fulfill specific needs and can be adapted, allowing clients to tailor their mirrors according to their unique requirements.

Bertin Alpao's Embedded Deformable Mirror is compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.



Furthermore, Bertin Alpao provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



DM Catalogue

eDM Technical Specifications

	eDM 57-15	eDM 69-15	eDM 97-15
Number of actuators	57	69	97
Actuator matrix size	9x9	9x9	11x11
Pupil diameter (mm)	9.0	10.5	13.5
Pitch (mm)	1.5	1.5	1.5
Number of actuators across a diameter	9	9	11
Active best flat (nm RMS, mechanical) _{max}	7	7	7

Tip/Tilt stroke (µm PV, wavefront) _{min}	60
Defocus/Astig stroke (µm PV, wavefront) _{min}	40
3x3 stroke (µm PV, wavefront) _{min}	25

Setting time (ms at -/ - 10%, any stroke) _{max}	
First resonance of the membrane (Hz) _{min}	800
Frequency at phase lag of 45° (Hz) _{min}	700

Mechanical W x H x D (mm)	51.5x74x55.9
Weight (g)	245
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Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminum and Dielectric

Functional temperature (°C)	-50 to 50
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)
Maximum floating actuator count	0

All main technical specifications are valid at a temperature of 21 \pm 4 °C.



DM Catalogue

Small Deformable Mirrors (DM) < 100 actuators

Bertin Alpao defines small Deformable Mirrors as mirrors who have less than 100 actuators. The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, Bertin Alpao's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Small Deformable Mirrors are ideal for applications where low-order optical aberrations need to be corrected, or where the system size and complexity needs



to be minimized.

Each Deformable Mirror is designed to fulfill specific needs and applications, varying levels with of actuator counts, aperture sizes, and strokes. Additionally, Bertin Alpao provides custom Deformable Mirror solutions, allowing clients to tailor their mirrors according to their unique requirements.

Bertin Alpao's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control

algorithms.

Furthermore, Bertin Alpao provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



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DM 57-15 Technical Specifications

	DM 57-15				
Number of actuators	57				
Actuator matrix size	9x9				
Pupil diameter (mm)	9.0				
Pitch (mm)	1.5				
Number of actuators across a diameter	9				
Active best flat (nm RMS, mechanical) _{max}	7				
Tip/Tilt stroke (μm PV, wavefront) _{min}	60				
Defocus/Astig stroke (µm PV, wavefront) _{min}	40				
3x3 stroke (µm PV, wavefront) _{min}	25				
A					
Settling time (ms at -/+ 10%, any stroke) _{max}	0.8				
First resonance of the membrane (Hz) _{min}	800				
Frequency at phase lag of 45° (Hz) _{min}	700				
Mechanical W x H x D (mm)	51.5x74x22				
Weight (g)	180				

Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2

Standard face sheet coating type	Protected Silver		
Optional face sheet coatings	Gold, Aluminium and Dielectric		

Functional temperature (°C)	-50 to 50				
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)				
Maximum floating actuator count	0				

All main technical specifications are valid at a temperature of 21 ± 4 °C.



DM 69-xx Technical Specifications

				
	DM 69-08	DM 69-15	DM 69-25	DM 69-50
Number of actuators	69			
Actuator matrix size	9x9			
Pupil diameter (mm)	5.6	10.5	17.5	35
Pitch (mm)	0.8	1.5	2.5	5.0
Number of actuators across a diameter	9			
Active best flat (nm RMS, mechanical) _{max}	7 25			25

Tip/Tilt stroke (µm PV, wavefront) _{min}	80	60	40
Defocus/Astig stroke (µm PV, wavefront) _{min}	40		30
3x3 stroke (µm PV, wavefront) _{min}	25		

Settling time (ms at -/+ 10%, any stroke) _{max}	1.5	0.8	1.5	
First resonance of the membrane (Hz) _{min}	400	800	600	600
Frequency at phase lag of 45° (Hz) _{min}	300	700	500	500

Mechanical W x H x D (mm)	51.5x74x35	51.5x74x22	62x84x23	100x120x40
Weight (g)	230	180	200	1000

Non-linearity (%) _{max}	3			
Hysteresis (%) _{max}	2	4		

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium and Dielectric

Functional temperature (°C)	-50 to 50				
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)				
Maximum floating actuator count	0				

All main technical specifications are valid at a temperature of 21 ± 4 °C.



DM 97-xx Technical Specifications

	DM 97-08	DM 97-15	DM 97-25	DM 97-50
Number of actuators	97			
Actuator matrix size	11x11			
Pupil diameter (mm)	7.2	13.5	22.5	45
Pitch (mm)	0.8	1.5	2.5	5.0
Number of actuators across a diameter	11			
Active best flat (nm RMS, mechanical) _{max}	7			25

Tip/Tilt stroke (µm PV, wavefront) _{min}	80	60	40
Defocus/Astig stroke (µm PV, wavefront) _{min}	4	0	30
3x3 stroke (µm PV, wavefront) _{min}	25		

Settling time (ms at -/+ 10%, any stroke) _{max}	1.5	0.8	1.5
First resonance of the membrane (Hz) _{min}	400	800	600
Frequency at phase lag of 45° (Hz) _{min}	300	700	500

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Mechanical W x H x D (mm)	51.5x74x35	51.5x74x22	62x84x23	100x120x40
Weight (g)	230	180	200	1000

Non-linearity (%) _{max}		3		
Hysteresis (%) _{max}	2	2	2	4

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium and Dielectric

Functional temperature (°C)	- 50 to 50
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)
Maximum floating actuator count	0

All main technical specifications are valid at a temperature of 21 ± 4 °C.



Large Deformable Mirrors (DM) > 100 actuators

Bertin Alpao large Deformable Mirrors are mirrors who have 100 or more actuators. The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, Bertin Alpao's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Large Deformable Mirrors provide finer control of the mirror surface, this



enables the correction of higherorder aberrations and better performance in various applications.

Each Deformable Mirror is designed to fulfill specific needs and applications, with varying levels of actuator counts, aperture sizes, and strokes. Additionally, Bertin Alpao provides custom Deformable Mirror solutions. allowing clients to tailor their mirrors according to their unique requirements.

Bertin Alpao's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless

integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, Bertin Alpao provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.



Large DM Technical Specifications

	DM 192-15	DM 256-15	DM 277-30
Number of actuators	192 256		277
Actuator matrix size	16x16	18x18	19x19
Pupil diameter (mm)	21	24	50
Pitch (mm)	1.	.5	3.1
Number of actuators across a diameter	16	18	19
Active best flat (nm RMS, mechanical) _{max}		7	15

Tip/Tilt stroke (µm PV, wavefront) _{min}	15	10
Defocus/Astig stroke (µm PV, wavefront) _{min}	10	
3x3 stroke (µm PV, wavefront) _{min}	10	

Settling time (ms at -/+ 10%, any stroke) _{max}	0.5	1
First resonance of the membrane (Hz) _{min}	2000	1100
Frequency at phase lag of 45° (Hz) _{min}	1500	1000

Mechanical W x H x D (mm)	70x110x82	100x120x60
Weight (g)	1000	
Non-linearity (%) _{max}	3	
Hysteresis (%) _{max}	2	

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium and Dielectric

Functional temperature (°C)	-50 to 50
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)
Maximum floating actuator count	1%



Large DM Technical Specifications

	DM 308-15	DM 468-15	DM820-15	DM 1433-26
Number of actuators	308	468	820	1433
Actuator matrix size	20x20	24x24	32x32	43x43
Pupil diameter (mm)	27	33	45	102
Pitch (mm)	1.5			2.6
Number of actuators across a diameter	20	24	32	43
Active best flat (nm RMS, mechanical) _{max}	7	7	7	15

Tip/Tilt stroke (µm PV, wavefront) _{min}	15	12	15
Defocus/Astig stroke (µm PV, wavefront) _{min}	10		15
3x3 stroke (µm PV, wavefront) _{min}	10		15

Settling time (ms at -/+ 10%, any stroke) _{max}	0.5		1.2
First resonance of the membrane (Hz) _{min}	1800	1600	800
Frequency at phase lag of 45° (Hz) _{min}	1400	1500	600

Mechanical W x H x D (mm)	70x110x82	90x110x124	100x120x120	153x180x180
Weight (g)	1000	1800	1700	5200

Non-linearity (%) _{max}	3	
Hysteresis (%) _{max}	2	3

Standard face sheet coating type	Protected Silver	
Optional face sheet coatings	Gold, Aluminium and Dielectric	

Functional temperature (°C)	-50 to 50
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)
Maximum floating actuator count	1%

All main technical specifications are valid at a temperature of 21 ± 4 °C.



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Large DM Technical Specifications

	DM 2844-25	DM 3228-15	DM 13107-15
Number of actuators	2844	3228	13107
Actuator matrix size	60x60	64x64	128x128
Pupil diameter (mm)	142.5	93	190
Pitch (mm)	2.5	1.5	1.5
Number of actuators across a diameter	60	64	128
Active best flat (nm RMS, mechanical) _{max}	15	7	7
Tip/Tilt stroke (µm PV, wavefront) _{min}	10	10	-
Defocus/Astig stroke (µm PV, wavefront) _{min}	10	8	• • • • <u>•</u> • • • • •
3x3 stroke (µm PV, wavefront) _{min}	10	8	-
Settling time (ms at -/+ 10%, any stroke) _{may}		0.5	· · · · · · · · · · · · · · · · · · ·

Settling time (ms at -/+ 10%, any stroke) _{max}		0.5	
First resonance of the membrane (Hz) _{min}	1000	1200	-
Frequency at phase lag of 45° (Hz) _{min}	800	1000	• • • • • • • • • •

Mechanical W x H x D (mm)	220x280x200	140x180x180	-
Weight (g)	12000	4800	• • • • <u>•</u> • • • • •

Non-linearity (%) _{max}		3	
Hysteresis (%) _{max}	3	2	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6

Standard face sheet coating type	Protected Silver
Optional face sheet coatings	Gold, Aluminium and Dielectric

Functional temperature (°C)	-50 to 50	
LIDT (for protected silver coating ²)	coating ²) 880mJ/cm ² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)	
Maximum floating actuator count	1%	

All main technical specifications are valid at a temperature of 21 ± 4 °C.



Large Aperture Deformable Mirrors (DMX)

The company's mirrors offer high stroke and resolution, allowing for the correction of large wavefront errors with nanometer-level precision. Furthermore, Bertin Alpao's mirrors boast high optical quality, low hysteresis, and minimal creep, enabling accurate and stable operation in demanding applications.

Large Aperture Deformable Mirrors boast a larger pupil diameter than other Deformable Mirrors. This larger pupil captures more light from the source, which



can be particularly beneficial when low-light conditions or when observing faint objects.

Each Deformable Mirror is designed to fulfill specific needs and applications, with varying levels of actuator counts, aperture sizes, and strokes. Additionally, Bertin Alpao provides custom Deformable Mirror solutions, allowing clients to tailor their mirrors according to their unique requirements.

Bertin Alpao's Deformable Mirrors are compatible with a variety of software platforms, including MATLAB, LabVIEW, and Python. This compatibility ensures seamless integration into existing systems and facilitates communication with various wavefront sensors and control algorithms.

Furthermore, Bertin Alpao provides comprehensive customer support, offering technical assistance, training, and workshops to help clients maximize the potential of their Deformable Mirrors.

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DMX Technical Specifications

	DMX 37	DMX 61	DMX 85
Number of actuators	37	61	85
Actuator matrix size	7x7	9x9	11x11
Pupil diameter (mm)	100	130	170
Pitch (mm)	20.6		
Number of actuators across a diameter	7	9	11
Active best flat (nm RMS, mechanical) _{max}	45	45	45
Tip/Tilt stroke (µm PV, wavefront) _{min}	30	50	50
Defocus/Astig stroke (µm PV, wavefront) _{min}	25	40	40
3x3 stroke (µm PV, wavefront) _{min}	25		
Settling time (ms at -/+ 10%, any stroke) _{max} 2			
First resonance of the membrane (Hz) _{min}	400		
Frequency at phase lag of 45° (Hz) _{min}		400	

Mechanical W x H x D (mm)	244x290x78	244x290x78	244x290x78
Weight (kg)	8.5	8.5	8.5

Non-linearity (%) _{max}	3
Hysteresis (%) _{max}	2

Standard face sheet coating type	Protected Silver		
Optional face sheet coatings	Gold, Aluminum and Dielectric		

Functional temperature (°C)	-50 to 50		
LIDT (for protected silver coating ²)	880mJ/cm² (@12ns, 10Hz, 1064nm) / 50W (CW @ 1064nm)		
Maximum floating actuator count	0		

All main technical specifications are valid at a temperature of 21 ± 4 °C.

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Deformable Mirror Electronics



The **Standard Electronics** are the default drivers for small

Deformable Mirrors. Powered manually via a on/off button, It ensures fast and efficient communication with Deformable Mirrors, enabling users to fully harness the capabilities of their Adaptive Optics Systems. The default connection is USB 2.0 / Ethernet. For clients requiring even higher-speed communication, a

Gigabit interface can be integrated, providing the flexibility needed to meet the most demanding requirements.

The **OEM Electronics** are available as an option for small Deformable Mirrors. They offer a compact form factor for systems in which space is crucial. The default connection is USB 2.0 / Ethernet. For clients requiring even higher-speed communication, a Gigabit interface can be integrated, providing the flexibility needed to meet the most demanding requirements.





The Large Electronics are the default drivers for large Deformable Mirrors. Powered manually via a on/off button, it allows the most precise control in order to correct high order complex aberrations. A gigabit interface is integrated by default. The number of Gigabit changes in accordance to the mirror purchased (a higher actuator count requires more connections).

A PCIe card can be integrated on request to all of our electronic drives.

	Standard Electronics	OEM Electronics	Large Electronics
Dimension W x H x D (cm)	31.5 x 13.5 x 23.5	10.9 x 12.5 x 25.9	37.1 x 17.5 x 45
Power consumption	<150W	<150W	<500W



Deformable Mirror Options

Variations of our mirrors are available under request:

- High Speed reduces the response time of the DM by a factor 2.
- Large Stroke increases the stroke of the DM by a factor 1.5
- **High Stability** is recommended for open loop applications, enhacing the stability of the DM. It is compatible with the Large Stroke option.

	Stroke	Settling Time	1 st resonance freq.	Freq. phase lag 45°
Large Stroke	x1.5	x2	x0.5	x0.5
High Speed	x0.5	x0.5	x2	x2
High Stability	x1	x1.25	x0.75	x0.75

Accessories



The **Rotation Stage** is available for our Deformable Mirrors depending on the model. It allows for precise tip-tilt correction and alignment of the mirror. A **Motorized Rotation Stage** is also available under request.



The **Alignment Static Mirror** is available for every Deformable Mirror. It uses the same housing as your mirror. It replaces your Bertin Alpao DM for alignment tests or when you must move your DM to another optical bench.



The **Trigger-IN and Trigger-OUT** cable allows you to synchronise sharply your DM with external hardware or vice-versa. This requires your Electronic Drive to have a PCIe card.



The **Ledbox** allows you to verify that the expected signals are arriving from your control computer to the deformable mirror.





Contact and support

Contact

Bertin Alpao commercial team is here to help you, both in the choice of a DM or any other technical information. Please contact us if you need to discuss your specific needs and projects at:

> contact.alpao@bertin.group +33 476 890 965 (9am to 5pm FRANCE TIME)

Support

If you face any issue during the installation or use of your Bertin Alpao setup, you can contact Bertin Alpao support, please send an email to, or call:

support.alpao@bertin.group +33 476 890 965 (9am to 5pm FRANCE TIME)

Please, provide a detailed explanation of the problem as well as the serial number of your product. A ticket will be created and we will contact you within the shortest delay possible.

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