A near-infrared high-resolution spectroscopic survey of Galactic bulge stars - JASMINE prestudy -

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ABSTRACT

We are developing a new near-infrared high-resolution (Rmax= 100,000) and high-sensitive spectrograph WINERED, which is specifically customized for short NIR bands at 0.9–1.35 μm. WINERED employs the novelty in the optical system; a potable design with a near-infrared immersion grating and a warm optics without any cold stops. The planned astrometric space mission JASMINE will provide the exact positions, distances, and proper motions of the Galactic bulge stars. The missing components, the radial velocity and chemical compositions, will be measured by WINERED with high accuracies (δV< 10km/s). These combined data brought by JASMINE and WINERED will certainly reveal the nature of the Galactic bulge. We plan to complete this instrument for the observation of a single object with a single slit by the end of 2008 and hope to attach it to various 4–10 m telescopes as a PI-type instrument. In succession, we will plan to develop it to the design for a similar spectrograph but with a simultaneous multi-object spectroscopic capability for full-fledged bulge survey.

I. Ground-based follow-up

- JASMINE - astrometric satellite
  position, distance, proper motion
- WINERED - ground-based high resolution spectroscopy
  radial velocity, chemical composition

→ Complete information on chemo-dynamics for the Galactic bulge

- high resolution (R_{max}=100,000)
- short near-infrared bands at 0.9-1.35μm
- one million bulge stars
- high accuracies of δV< 10km/s
- a single object use → a simultaneous multi-object use

II. What's "WINERED" ?

- WINERED = "Warm INfra-red Echelle spectrograph to Realize Extreme Dispersion"
- near-Infrared echelle spectrograph, R=100,000
- very high sensitivity (T.P. > 25 %) and portable (see Table 1)
- PI-type instrument for 4 – 10 m telescopes
- completion to build: the end of 2008

	immersion grating mode	normal echelle mode
Spectral resolution	Rmax =103,000	Rmax =28,300
Wavelength range	λ = 0.9 – 1.35 μm (z, Y , and J bands)	
Wavelength coverage (which can take a single exposure)	0.90 – 1.07 μm (z-mode) 0.96 – 1.11 μm (Y-mode) 1.12 – 1.35 μm (J-mode)	0.93 – 1.35 μm
Instrumental volume	< 1500 mm(L) × 500 mm(W) × 500 mm(H)	
Telescope	D = 4 – 10 m (f/11 at Nasmyth forcus)	

Table 1: Summary of specifications of WINERED

III. Two approaches of WINERED

II-1. Warm Optics

- a warm optics with no cold stop
  (only a camera and detector array are cooled)
- realized by specifying the wavelengths of 0.9 – 1.35 μm
- limitation of λ improves AR coating performances

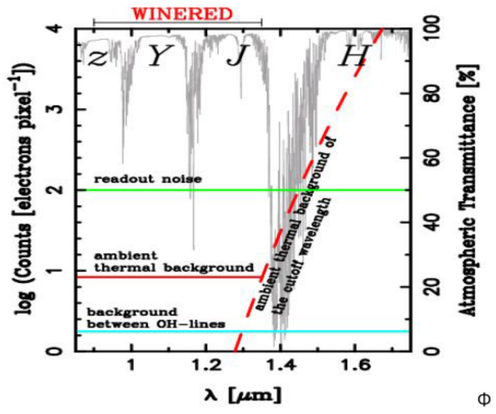

Figure 1: Comparison of three background levels, (1) readout noise by the readout system, (2) Ambient thermal background, and (3) sky background between OH lines.

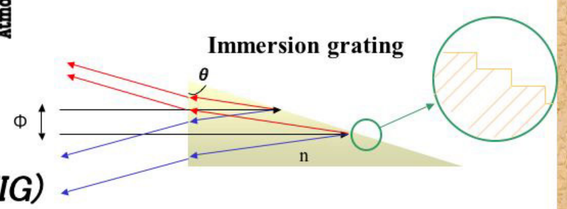

Figure 2: Schematic view of immersion grating

II-2. ZnSe immersion grating (ZIG)

- spectral resolution formula for an echelle grating
  $R = 2\,n\,\Phi\,\tan\theta\,/(s\,D)$
  n: index of grating material, Φ: collimated beam size
  θ : blaze angle, s: slit size (rad.), D: telescope diameter
- ZMG (n=2.4) can significantly reduce Φ, therefore the volume of instrument !!
- under the test groove processing on ZnSe pieces using the ELID grading method. See figure 3.

IV. Optical system and Electronics

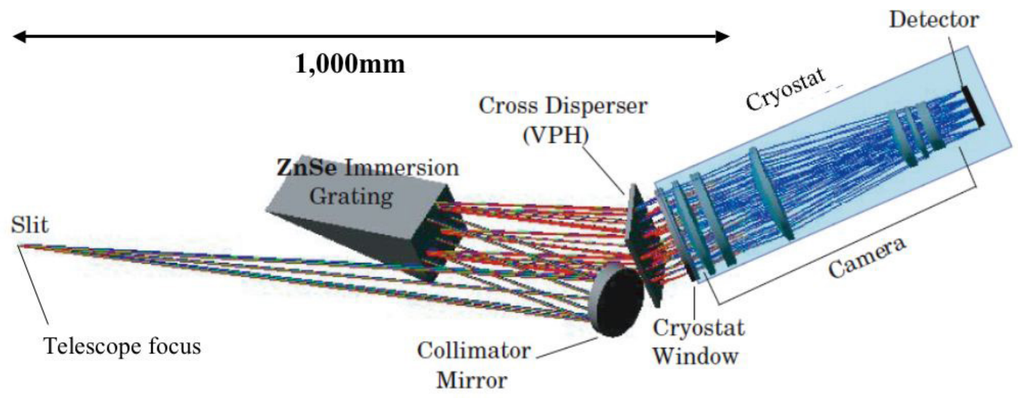

Figure 4: Optical layout of WINERED

Table 2: Specification of ZIG

Material	ZnSe (n ∽ 2.4)
Clear aperture	90 mm x 90 mm
blaze angle	70 deg.
Groove density	31.52 lines mm^{-1}
Coating	AR coating at the entrance/exit surfaces Au or Ag coating at the diffraction surface

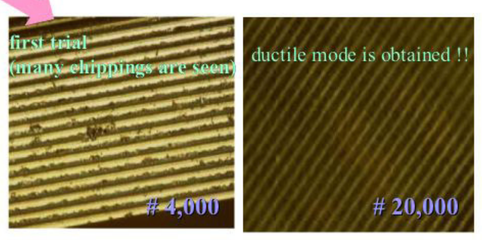

Figure 3: Results of processing tests on a ZnSe piece by ELID method